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THE SCIENTIFIC MONTHLY

AUGUST, 1922

THE GEOLOGIC EVIDENCE OF EVOLUTION

By Professor EDWARD W. BERRY

THE JOHNS HOPKINS UNIVERSITY

ONE of the outstanding, possibly the only difference between man and the other animals is his ability to profit by the experience and accumulated wisdom of the race, and yet, despite this characteristic, each generation seems to produce its quota of anti-vaccinationists, anti-evolutionists and believers in a flat earth. We may still entertain the hope that the race is becoming more rational when we recall that it has taken about three centuries to convince the Anglo-Saxon and a few other races among the countless millions of the globe that the earth is not flat, so that to-day only the leader of Zion City (Voliva) among leading cosmologists defends the pentateuchal view.

I do not wish to be thought of as sneering at any one's beliefs, and I fully realize that there are a great many earnest Christian men and women who are perturbed at anything that they think, rightly or wrongly, will shake the foundations of their faith, who are puzzled by the present outspoken opposition to evolution, and who wish to know what is the truth. No truer article of faith was ever penned than the motto of the Johns Hopkins University—*Veritas vos liberabit*—and to you seekers after truth I would like to explain away certain misconceptions, before undertaking to show you that the record of earth history is the record of evolution, and not to be disputed by honest people.

Evolution is not a theory of origins, nor an article of scientific faith, but an indisputable fact. We could not teach geology without teaching evolution. One of the difficulties to the layman is the confusion of evolution—the record of the past and present history of organisms—with the various theories that have been proposed to explain its factors or mode of operation. Let me emphasize that evolution, the record, is in an altogether different category from the theories such as Darwinism, Lamarckianism, or any other

ism that has been advanced to explain its working. You may flout all the theories or you may advocate one of a dozen different theories, but this has nothing to do with the history of life. We, in geology, spend much time in going over the history of organisms, but pay but slight attention to the theories—at least in our teaching.

A simple illustration of the once universal and now fortunately less frequent clerical reaction to evolution will make clear what I am driving at. Evolution was regarded as a dangerous heresy, inimical to Christianity, contrary to Genesis, which was regarded as a scientific account of the origin of the earth and its inhabitants. Do these people claim that the hundreds of varieties of horses, dogs, chickens and pigeons go back to the Garden of Eden, or were in Noah's ark, or that all the horticultural varieties of flowers, shrubs and vegetables were in Mother Eve's kitchen garden? *Not at all!* They are more or less familiar with the cattle breeders or the Burbank method of artificial selection. Their objection to evolution rests on the assumption that man is of a different stuff from the brute world—as if they had had no experience with congregations or legislative assemblies. It is the implied collateral relationship with monkeys, and the tradition engendered by medieval art that the devil has a tail that offends their dignity.

The statement that the human species is descended from monkeys is merely polemical obscurantism and the playing on prejudices that started with Bishop Wilberforce—soapy Sam as he was called by some of his contemporaries—and is a sort of Bryanesque smoke screen. As to lineage, man is not at all closely related to the existing monkeys or apes. They are the culmination of different lines of evolution, and this statement is especially true of the monkeys. That their ancestry in the far distant past approximated the human line or indeed may have merged with it millions of years ago in early Tertiary times is quite another matter.

I find nothing in Genesis either for or against evolution. The language, to be sure, is not explicit (dust of the earth), but the special creation of man as opposed to the evolutionary creation is entirely an egoistical interpretation that is supposed, quite wrongly it seems to me, to add dignity to ourselves, and is of a cloth with the idea that the earth is the center of the universe—all the earth (homocentric) centering in man, and all the universe revolving around the earth—man's temporary abode. It is a most curious revelation in the workings of the human mind that so many good people grow indignant over the idea that man was made from a long line of animal ancestry as degrading; and yet who do not

quarrel with the facts that each human starts his or her individual life as a single cell, and during the nine months preceding birth passes through a series of stages that roughly epitomize the main stages of evolution, even to possessing a rudimentary tail like an ape. Five hundred years ago we should have said that embryology was the invention of the devil to test the faith of the elect—exactly a reason that was once advanced to explain the fossils in the rocks. To-day most of us know better, and we find in the truth of creation far more to reverence than in the anthropomorphic deity of the childhood of the races.

In approaching the geological record of evolution, I will state only facts and leave fundamental causes severely alone. The mechanism of evolution we leave to experimental biology, and I do not advocate any theories of explanation. Here is evolution. Here are the myriad of forms that moved across the stage of the past and were the actors in the drama of life. In geology, to borrow a simile from written history or philology, we are dealing with the original documents in so far as they were preserved as fossils, and in their actual order of succession.

In approaching the geological record, the time conception is most important, and I can best illustrate this by a brief recital of the progress of knowledge concerning fossils. It is only in comparatively modern times that fossils have been recognized as the remains of animals and plants that had once been alive. The early Greeks were sane enough to recognize this apparently obvious relationship, and we find Xenophanes, 500 B. C., speculating on the fossils found in the quarries of Syracuse, Sicily. But during the middle ages there was no end to the discussion regarding the nature and origin of fossils. What seems strange in this year of grace may really not have been so strange in the days when the universally held belief was that of spontaneous generation, a flat earth created in six days, and the only past submergence of the land that of Noah's flood. Was it not the same "plastic force" in nature which traced the frost patterns and the moss agate that fashioned the fossils, and was there not every gradation from shells and bones that exactly resemble recent ones to mere stones of similar form and appearance? We now know that the mineral replaces the organic matter of a fossil. Was it strange to have believed three or four hundred years ago that the process was the reverse—from the mineral toward the organic? At any rate many strange theories were evolved to explain the fossils. One tells us that fossil shells were formed on the hills by the influence of the stars. Others called up a stone-making spirit. Others believed that fossils were the models made by the Creator in perfecting his handiwork before

he essayed the task of making living organisms. I am quoting entirely the views of devout churchmen. Others believed that fossils were mere "figured stones," or were the abortive products of the germs of animals and plants that had lost their way in the earth, or that they were the invention of the devil to test the faith. Even after the belief that fossils were the remains of animals and plants had become well established, it was assumed that they had been killed by Noah's flood and stranded on the mountain tops—an interpretation suggested by Martin Luther in 1539 as secular proof of the correctness of the scriptural account. This flood theory found numerous advocates throughout the seventeenth and even far into the eighteenth century. It passed through various phases of opinion. At first, the fossils were regarded as similar to those still living in the vicinity—a natural enough belief when the universal acceptance of the Mosaic cosmology and a world but 6,000 years old is borne in mind. Later, when the differences in the fossils became apparent, it was assumed that they had been swept to Europe and buried by the waters of the flood and represented forms still existing in the tropics. With the progress of knowledge of tropical organisms this last view became untenable, and it was thought that the fossils represented forms that had been exterminated by the flood, and from this it was but a slight step to the once popular belief that there had been no thistles or weeds or noxious insects in the Garden of Eden, that all creation had become base with the fall of man. Gradually it came to be recognized that fossils were not only frequently unlike recent organisms, but that they were very ancient, and not merely antediluvian, but pre-Adamitic—a view first advocated by Blumenbach in 1790. We are still far from a chronology. Granting that fossils were the traces of once living organisms and antedated Adam—what of it? When Guettard (Jean Etienne Guettard, 1715-1786) made one of the first geological maps, it wasn't really a geological map in the modern sense, but a map of what he called mineral bands (like a modern soil map). He had no idea of geological succession or of structure. The credit of recognizing fossils as the modals of creation we owe to the genius of William Smith (1769-1839) and to the orderly arrangement of the Mesozoic rocks of the English Midlands. Smith journeyed about for years in this region, where the succession of fossiliferous strata is an open book. In his work of building canals, roads and drains, he observed that each bed contained fossils, some of which were peculiar to it, and he found that he could recognize the same horizons and the same succession at many different localities.

This important generalization has since been verified and end-

lessly extended. The contained fossils furnish the surest guides to the age of the sedimentary rocks that geology knows. To the biologist these facts have a deeper meaning, for they show that during the vast lapse of time, to be measured in tens or hundreds of millions of years, the living population of the globe has undergone almost continuous change, old simple forms becoming extinct, and newer, more specialized, forms taking their place, the change being, in general, from lower to higher, in other words—evolution.

That God rested from his six days' task of creation just 4004 years B. C. is so absurd that I have yet to meet a person of normal mind who believes in Archbishop Usher's chronology. There have been many attempts to determine the age of the earth in years—calculations of the rate of cooling of molten bodies, the rate of retardation by tidal friction, the thickness of the sedimentary rocks, the amount of dissolved salts added to the oceans by the rivers of the world, the condition of the radium minerals in igneous rocks. All methods contain unknown variables and are merely estimates. A favorite method has been to measure the thickness of a composite section of the sedimentary rocks, for the whole

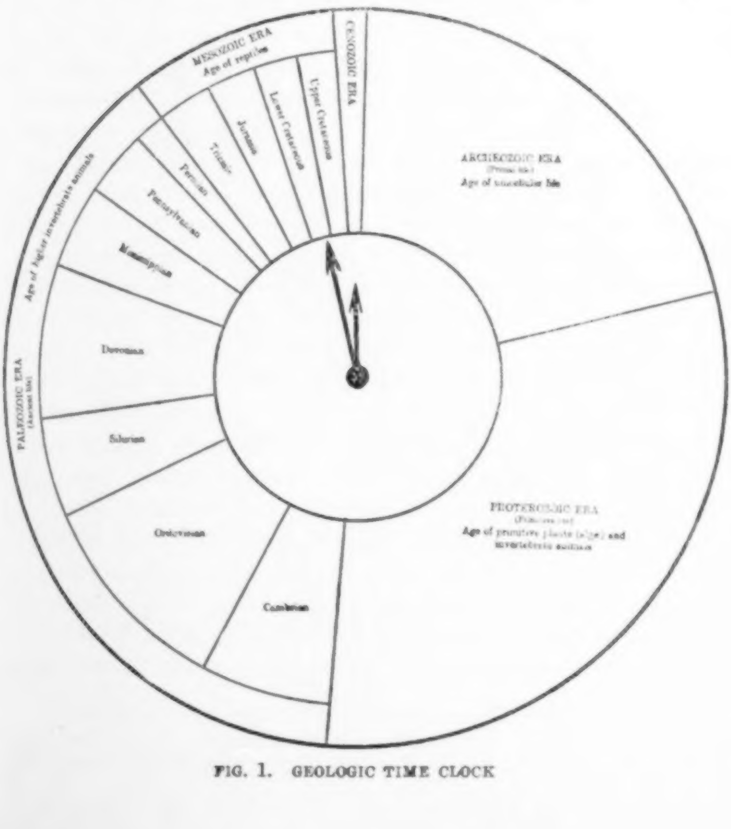

FIG. 1. GEOLOGIC TIME CLOCK

record is not complete in any one section—seas and sediments shifted with the incessant change in geographic pattern. If they had not, we should have such a perfect record of evolution with no missing chapters that we should be able to establish geological time boundaries between rock formations or biological boundaries between animal and plant groups.

The measurement of thicknesses has this advantage, that whereas its results expressed in years are not accurate, its results expressed in relative ratios of duration for the different geological periods are fairly so. I have sought to show the totality of geological time reckoned in this way in the form of the face of a clock in which the dial represents the total thickness of sedimentary rocks divided among the different geological periods in the proper ratios. With this perspective I wish to pass in review in an untechnical way some of the facts of evolution. Obviously, one can not go into details in a brief hour, nor present the links in the chain of evidence, or talk about the septa and sutures of the ammonites, the pygidia of trilobites; or the frontal, parietal, temporal and other bones of the vertebrates.

Show us one species changing into another, and we shall believe in evolution, says the bigot, expecting to see an Alice-through-the-looking-glass transformation of cats into dogs or rabbits into porcupines, not realizing what a species is, or the slowness with which very obvious new characters are acquired as measured in terms of human years. If they had been present through any 70 years of geological time, they would have seen no more evidence of evolution than they see to-day. The first man to see the transformation of species was Waagen,[2] an Austrian geologist and paleontologist, who, in 1869, in the successive layers of fossiliferous Jurassic rocks, observed the minute and inconspicuous changes of form in a definite direction, resulting as they increased in magnitude in the gradual emergence of successive new species of ammonites (Oppelia). These observed grades of difference or nuances (Waagen termed them mutations) are the more gradual and inconspicuous the more abundant the material studied, or the finer our analysis of it. This observed gradual evolution of adaptive characters is quite the opposite of Darwin's theoretical idea of the natural selection of chance variations, and its abundant verification among all groups of fossil organisms wherever an abundance of successive faunas or floras are available for study is one of the reasons why paleontologists have never been strong Darwinists, but

[2] Waagen, Wilhelm Heinrich: Die Formenreihe des Ammonites subradiatus. Versuch einer Paläontologischen Monographie. Geognostisch-Paläontologische Beiträge. Bd. 2, Hft. 2, pp. 179-256, pls. 16-20, November, 1869.

have emphasized the environment as the main stimulus of variation. Discontinuity is observed only in characters where continuity is impossible, as in changes in the number of teeth or vertebra. I could spend days showing you these evolutionary series of trilobites, brachiopods, crinoids, molluscs, etc., but they are not especially convincing without fullness of knowledge and presentation, and are not nearly so impressive to a lay audience as the more obviously discerned, but identical, series among the higher vertebrates. There is probably no group of organisms as ideal for evolutionary studies as are the Ammonites—extinct relatives of the pearly Nautilus. Their shells are preserved in tens of thousands in the Mesozoic and earlier rocks. From the time the embryo formed its first shell until death, each successive stage is preserved in calcite within the enrolled shell. If you would see the size, form and details of ornamentation of a baby, adolescent or mature shell, all you have to do is to break away the outer shell. No other fossils furnish a complete life history with each individual. Moreover, the repetition of phylogeny during ontogeny is beautifully shown, as well as the inheritance of acquired characters, so

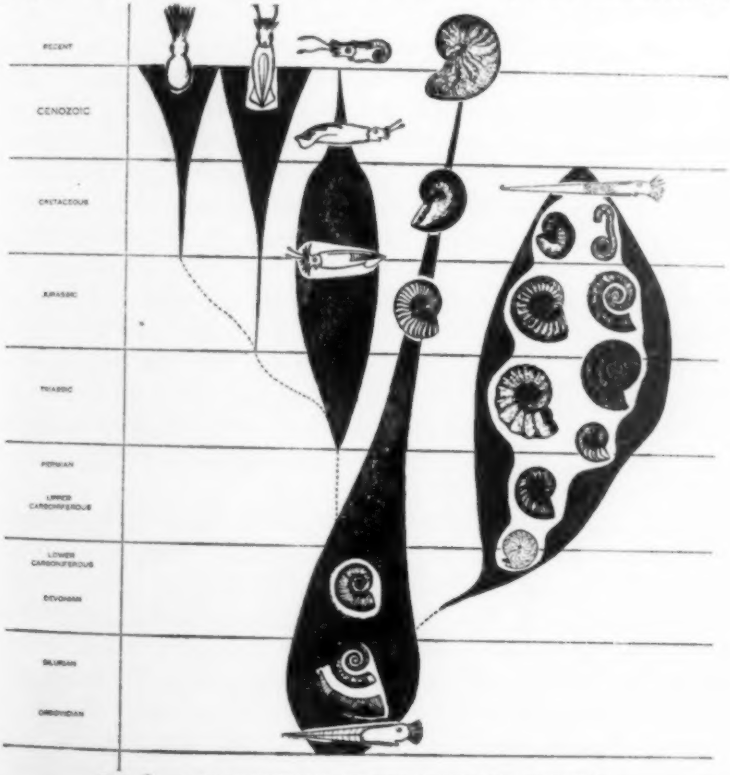

FIG. 2. THE EVOLUTION OF THE CEPHALOD PHYLUM

that we know the ammonite descent much better than we do that of many still existing groups of organisms. The main outlines of the evolution of the Cephalopods, to which group the ammonites belong, is shown in its chronological setting in Figure 2. Observe the gradual transformation of straight camerated shells becoming curved, then loosely coiled, then tightly coiled, giving rise to forms with angulated floors to the living chamber, the parent stock waning with the rise of the daughter stock, and represented to-day by a single living type, the pearly Nautilus. This daughter stock waxing great during Mesozoic times, we know 10,000 different species, gradually reaching overspecialization or racial senility, displayed in the progressive uncoiling and bizarre ornamentation of the shells, and finally passing off the stage altogether. A second main line of descent leads from the ancient Nautilus stock in the direction of animals whose soft parts outgrew their shells, retaining them within the mantle. This second line waxed abundant during Mesozoic time, and then waned in competition with its more perfected progeny, being represented in existing oceans by the single form, Spirula, which in its extreme youth lives in a tiny chambered shell like that of its remote ancestors, but soon outgrows this shell, and for the rest of its life carries this eloquent witness of its ancestry within the hind end of its body. You might remain incredulous before a single Spirula, but when you can trace throughout the records of hundreds of thousands of years the gradual subordination and progressive decrease in relative size of the shell and increase of the soft body, the meaning is unmistakable, and to corroborate the correctness of our reading of history, we have the more modern group of squids and cuttles with all of the morphological features of the Spirula stock, which solved their problem by modifying the now useless shell into an internal axis of support and are otherwise entirely soft bodied and often of large size; and, finally, the latest evolved group—the Octopoda—smaller less active forms, having slight need for the axis of the more elongated and actively swimming squids, have lost all traces of the ancestral shell.

Another great phylum of invertebrate animals (Echinoderma) starfishes, sea urchins and crinoids, have a wonderful abundance of fossil forms and well-ascertained relationships. Their history shows a worm like ancestor developing a plated exoskeleton of many irregular pieces; the progressive reduction in number and the assumption of definite form of these pieces—the radial symmetry impressed by the habit of stalked attachment—the various lines of descent which sought to increase the food gathering mechanism by extending the parts concerned over the test or rais-

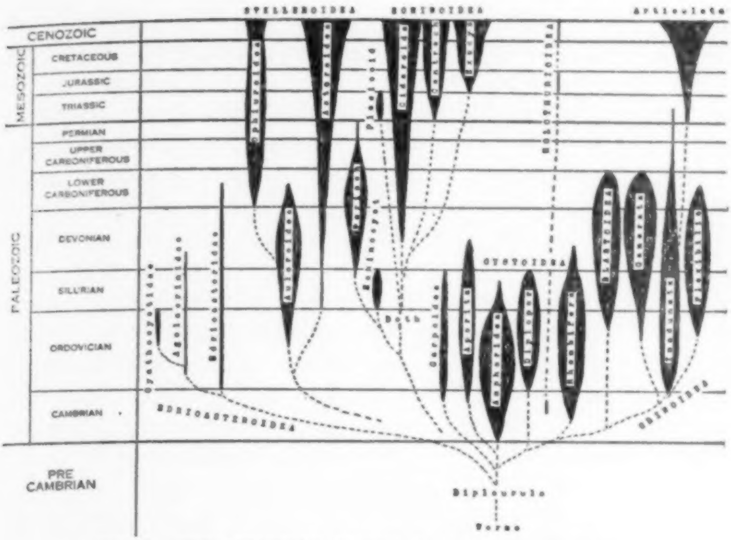

FIG. 3. THE EVOLUTION OF THE ECHINODERM PHYLUM

ing them on long arms—the reversed orientation of the errant urchins and starfishes—the one time dominance of specialized crinoids—the late evolution and present abundance of the free-swimming forms with flexible skeletons—the intermediate or synthetic character of the earlier forms, especially well shown in the Ordovician to Lower Carboniferous ancestors of the starfishes and serpent stars—all afford an excellent chapter in nature's record of evolution.

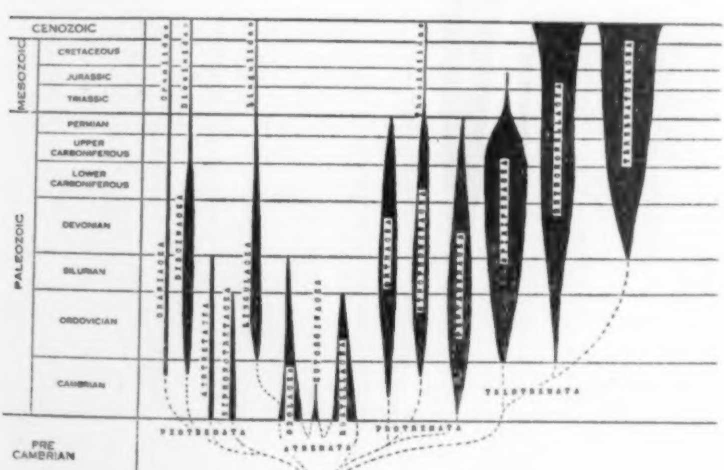

FIG. 4. THE EVOLUTION OF THE BRACHIOPOD PHYLUM

A group of invertebrates unknown to the layman, but immensely important to the paleontologist, whether he be interested merely in chronology or in evolution, is the Brachiopoda—the bivalved lamp shells of the ancients. The stock is very ancient and shows the most intricate series of gradating forms from the ancient hingeless Atremata, long since extinct except for a single family, which in Ordovician times modified its stalk of attachment into a burrowing organ, and from that time to the present has lived on practically unchanged in an unchanging environment of foul mud inimical to higher forms of life, sharing with the similarly reduced representatives of the two other primitive groups a record of unmodified habits or form in an unchanging environment that has enabled them to come down to the present, although all of their early relatives have long since passed off the stage of existence. Contrast the dwindling history of these families as represented by the black of their life lines with the series of forms, each step in whose history we have represented, of those which perfected hinge mechanisms—a protective device, and internal hard parts—loops and spirals for greater efficiency in collecting food and oxygen. We can see these structures grow until at the present time the few unchanged survivors of the more primitive orders are outnumbered fifty to one by the loop-bearing forms which retained the habit of protruding their so-called arms in search of food, whereas the spire-bearing forms that developed along with them in Paleozoic times had their arms fastened to their spiral supports and non-protrusible, and hence faded out of existence in the earlier half of Mesozoic times.

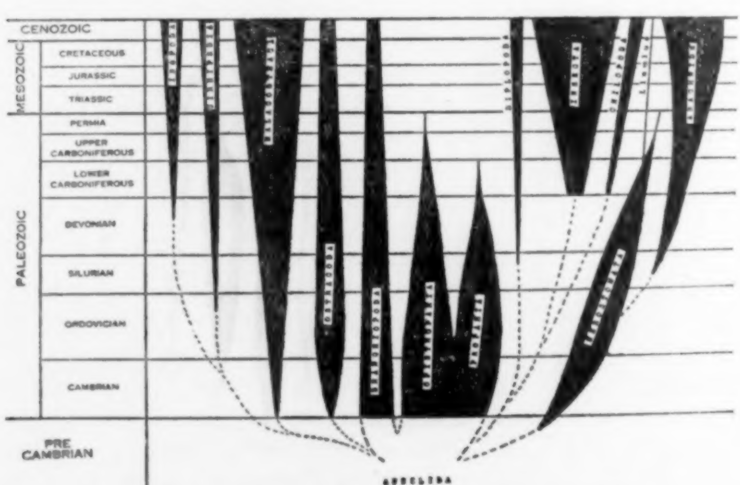

FIG. 5. THE EVOLUTION OF THE ARTHROPOD PHYLUM

A fourth great group is the Arthropoda, embracing the hosts of articulated animals whose relationships are shown, with the early evolution of the aquatic types—trilobites, crustaceans and Limulus-like forms. They exhibit the early efflorescence of the less specialized as to parts, and less protected as to armor—the trilobites; the relative late evolution of their terrestrial descendants—the spiders and centipedes, and the latest appearance of the aerial forms with specialized larval stages—the insects. Most interesting to see displayed among these myriad of diverse forms insects, spiders, crabs and ticks, their community of origin and the impress of their remote trilobite-like ancestry.

Either these myriads of slightly differing forms in progressive or retrogressive series represent evolution, or each slightly changed faunal and floral assemblage represents an independent act of special creation. These are absolutely the only alternatives, and the advocates of special creation, little as they seem to realize it, have to assume a creator, who every few years during a period of hundreds of millions of years mechanically fashioned new sets of organisms. Not only so, but each new set was fashioned surprisingly like their predecessors, sometimes with vestigial, useless or even harmful organs. It seems to me that this only logical application of the special creation hypothesis is a *reductio ad absurdum*, a bare statement of which is sufficient to demonstrate its obvious falsity. I would offer for the religiously inclined Henry Drummond's dictum that evolution was God's method of creation.

The complete epitome of vertebrate evolution showing the range in time and relative abundance deserves a word of comment. I should like the critics of evolution to explain why the most primitive vertebrates appear twice as far back in the record as any of the others, and why the different classes appear in the actual order from the less to the more evolved—from lower to higher—the fish-like amphibians appearing during the Devonian, the reptiles during the Upper Carboniferous, and the two lines to which the latter gave rise, the mammals and birds in the upper Triassic and upper Jurassic, respectively.

Is it not most unfortunate for evolutionary sceptics that the most ancient fossil bird should be one of the best and most spectacular fossils—feathers and all preserved with great fidelity in the fine-grained lithographic stone of Solnhofen—and should represent virtually a modified and partially feathered reptile, 25 per cent. reptile and 75 per cent. bird. About the size of a crow, the head was billess and the jaws were armed with true teeth, the wings had three free-clawed fingers, the tail was long and lizard-like, of 20 vertebræ, with pinnate feathers and not consolidated

with digitate feathers, the hind legs were wide apart and far back, with distinct tibia and fibula as in the reptiles, with the three pelvic bones distinct as in reptiles with no body feathers, the latter on only the wings, legs and tails—with feeble flight and obvious volplaning habits. (Archæopteryx or lizard tailed bird of the upper Jurassic.)

Before taking up man, I have time to consider but two among the many groups of mammals whose history is almost completely known. You doubtless think of elephants in North America only in connection with zoological gardens or circuses, and yet the elephants were a most conspicuous element of the American fauna from the middle Miocene to the end of the Pleistocene, and numerous bones and teeth have been found here in Maryland. They lived in America much longer than has the human race and much longer than the bears which we commonly think of as characteristically American. The elephants were originally immigrants from the old world. They occupy to-day a somewhat isolated position among hoofed mammals and display a curious but readily understandable mixture of specialized and primitive characters. Their specializations are in head and teeth, their conservatism is in body and limbs. To understand their ancestry, we must understand the five or six African and Asian species of the present. Their most obvious feature is the long trunk or proboscis that gives the name Proboscidia to the order. This trunk is simply an elongated nose, although it did not come into existence in the way Kipling relates. Aside from the trunk the tusks mark the elephant. These are simply much modified upper incisor teeth. The dental formula is then $i\frac{1}{0}\ c\frac{0}{0}\ pm\frac{0}{0}\ m\frac{3}{3}$ This is not the whole story of the teeth, however, for, if you examine an elephant's teeth, you will rarely find more than a single immense functional grinder in each jaw ramus—the milk molars, developing serially 1, 2, 3, and followed in turn by the molars 1, 2, 3 during life—the worn ones being pushed forward and out, a contrivance for increasing the elephant's life span, for an animal is only as long lived as its teeth. The mechanics of trunk and tusk support have specialized the head; cranial bones are thickened and lightened, hence the difficulty of shooting an elephant in the brain. The neck is shortened to bring the head weight nearer the withers. The body is long and massive with large shoulder and hip bones. The feet are short and broad with the nail-like hoofs around the edge. Toes are five but not all hoofed (Indian 5 in front, 4 behind; East African 4 in front, 3 behind). Limb adaptations are those common to all heavy animals of other stocks. Most quadrupeds have knee and elbow per-

manently bent. Great weight necessitates the straightening of the limb and individual bones and the shifting of the articular surfaces from an oblique to a right angled position. Weight of tusks causes a shortening and heightening of the skull. Shortening brings the weight arm of the lever nearer the fulcrum at the neck, and heightening lengthens the power arm and affords attachment for the increased musculature. (Modern tusks weighing 239 lbs. each are recorded.) The lengthening of the trunk makes it unnecessary for the mouth to reach the ground for food and water.

The earliest known fossil elephant, only a potential elephant, was of upper Eocene age and comes from near Lake Moeris in the Fayûm, and was consequently christened Moeritherium. It was small and somewhat suggestive of a tapir. The skull was long and narrow, the trunk was merely a snout, the neck was moderately long and the limbs were slender. The teeth were the most signicant feature. Formula $i\frac{3}{2}\ c\frac{1}{0}\ pm\frac{3}{3}\ m\frac{3}{3}$ First upper incisor was small and simple, the second was a downwardly directed small tusk. The third and the canine were non-functional and there were 6 grinders, simple and quadritubercular (4 cusps and 2 crests). In the lower jaw the incisors were procumbent. The first long, the second an enamelled tusk with worn chisel edge; the third and canine already gone and 6 grinders. The second stage of elephant evolution was Palæomastodon of the lower Oligocene of the same region. Several species are known, ranging in size from that of a modern tapir to a half grown Indian elephant. Tooth formula $i\frac{1}{1}\ c\frac{0}{0}\ pm\frac{3}{2}\ m\frac{3}{3}$ canines have gone; the incisors are reduced to a single tusk in each jaw ramus, *i. e.*, two upper and two lower tusks. All the grinders are functional, but they have increased in complexity and now consist of six cusps and three crests. The trunk was still short, the head still long and narrow, the limbs heavier, but still relatively light. The elephants now spread into southern Asia and over Europe during the lower Miocene, giving rise to various collateral lines of evolution along their different routes of dispersal. They increased greatly in size and became more elephantine in appearance. They reached North America during the middle Miocene, and these four-tusked forms spread from Nebraska to Florida. The old-world stock shortened the chin and lost the lower pair of tusks during the Pliocene, giving rise to the mastodons and mammoths of the late Pliocene and Pleistocene, which reinvaded North America and ranged southward to the straits of Magellan. Our mastodon survived much later than the European mastodon, and the males sometimes show vestigial tusks in the lower jaw. The mammoth was the contempo-

rary of early man in Europe as the many excellent carvings of the stone age show, and probably also in North America, as somewhat vaguely pictured carved bone and associated flints indicate. They were so common over the northern hemisphere at that time that we have records of 1,635 fossil tusks, averaging 150 lbs., being exported from Siberia in a single year. Between 1820 and 1833, trawlers out of Happisburg, Norfolk, dredged 2,000 elephant molars from the submerged old land of the North Sea. (We had three true elephants in America during the Pleistocene—the Northern or Hairy Mammoth, the Southern or Columbian Mammoth, and the Imperial Mammoth, the latter standing 13 feet at the shoulder.)

The family tree of our noblest of domesticated animals—the horse—has been called the example *de luxe* of evolution, since no animal stock is more completely known or has a more spectacular history. Long domesticated the modern animal is found almost everywhere that man can live, and of many breeds. As wild animals, horses are found only in the Old World in modern times—the arid plains of Central Asia and Africa. There are several species—horses, asses, zebras and quaggas—very uniform in tooth and skeletal characters, but strikingly different in appearance, because of the superficial difference in coloration and in the development of forelock, mane, tail and ears. They differ from all living animals in having a single toe on each foot. Their remotest ancestors were small five-toed plantigrade animals as were all of the earliest mammals. Hosts of fossil species are known, some extinct side lines especially adapted to certain environments, like the small mountain horses or the forest-dwelling and softer ground-inhabiting forms. Others were a part of the progressive line. The earliest known fossil horse you would not recognize as a horse. How do we know it was? By tracing backward step by step from the known. Nearly every stage of this ancestry is now complete, and we are as certain of the remote Tertiary form as we are of the present cart horse. The earliest well-known ancestral horse is the tiny Eohippus or Dawn horse of our early Eocene. It was about the size of a fox terrier, *i. e.*, 11 to 14 inches high, with a short neck, long body, arched back, short legs and small teeth. The front feet had 4 functional toes, and a splint representing the first or thumb. The hind feet had 3 functional and 2 splints representing the first and fifth. It is significant that at that time the ancestral horse line is so generalized that a layman could not distinguish it from the contemporaneous ancestral rhinoceroses or tapirs.

The second-stage Protorohippus of the middle Eocene was

about the size and proportions of a whippet hound. The thumb splint had now disappeared from the front foot, and the little finger splint from the hind foot. The weight was beginning to center on the middle toe, but it required two or three million years more to completely suppress the lateral toes. If there were time, we might pass in review each stage of horse evolution—the Epihippus of the upper Eocene, the Mesohippus of the Oligocene, about the size of a sheep, the Miocene, Protohippus, Pliohippus, Neohipparion, etc. The upper Miocene Protohippus is in the direct line and may be briefly characterized. About 40 inches high, longer head, longer teeth, deeper jaws, shortened body, longer legs and feet, only the third toe normally reaching the ground, but the second and fourth were complete "dew claws" and helped to support the weight on soft ground. There were many varieties of three-toed horses, and in the late Tertiary they had spread pretty well over the world, being found in South America, Europe and Asia, as well as in North America. By Pleistocene time the horses had become monodactyl, varied, abundant and wide ranging. So countless were the herds that the Sheridan formation of the West was long known as the Equus beds from the abundance of their fossil remains. When, however, America was discovered, horses had become extinct in the western hemisphere as well as in native tradition, although their bones are found associated with flint implements, pottery and fire refuse. They appear to have first been domesticated during the Neolithic, that is about 7000 B. C. in Europe, but probably at a much earlier date in Asia. Our modern work horse is descended directly from the European Neolithic horse, which was much like the Celtic pony. Descendants of this low-bred primitive race were distributed over Eurasia, where they are still represented by the Norwegian and Mongolian ponies. All the earlier horses of written history belonged to this type. It was improved by importations from Libya—the Arabs, for example, getting stallions and brood mares from Barbary, where the stock had suffered no ill effects during the Pleistocene glaciation, there having been no severity of climate in northern Africa. The course of evolution in the horses was not confined to the feet. It may be summarized as follows:

Along with the disappearance of side toes went increase in length of leg and foot, especially the distal portion. Increased length of the lower leg and foot increased length of stride and, as the chief muscles are in the upper leg, the center of gravity was changed very little, consequently the swing was about as rapid but mechanical strain was greatly increased, so that strengthening at the expense of flexibility by consolidation of the lower leg and

arm bones and conversion of ball and socket into pulley joints (ginglymoid) occurred. Lengthening of limbs for speed in grazing animals necessitates lengthening of the neck. Loss of toes was a hard ground adaptation for speed. The lengthening of the teeth which caused the deepening of the jaws was an adaptation for hard food and ensured more thorough mastication and a longer life span. Increase in size, although demanding an increased food supply, is a better defence against enemies or competitors. The evolution of the horse was from forest and swamp to grassy plains and went hand in hand with the evolution of the environment. Since monkeys are unaccountably not fashionable and we are very fond of horses here in Maryland, I show you for comparison a skeleton of a modern horse and man. Not only in the structure of all his physical parts, bone for bone, muscle for muscle, and nerve for nerve, is man fundamentally like the other mammals, but his specific organic functions are identical. We have the same diseases; we are similarly affected by the same drugs—in fact the whole wonderful advance of physiology and experimental medicine is built up on this truism. Have you ever thought of the countless generations of meat-eating humans involved in the specialization of the two human tape worms—the one passing its intermediate stage in beef and the other in pork and of which man alone is the host of the adult stage. The pre-humans were not meat-eaters, and we should not fail to take into account the improvement in nutrition in shortening the digestive processes and the stimulating properties of the proteins and their split products that a change in diet gave our ancestors the energy for other things.

I have already mentioned the remoteness of man's relationship with the existing monkeys and apes. Unfortunately, we have but slight knowledge of the earlier stages which remain hidden in the unexplored regions of Asia and Africa, to which much evidence points as the original homes of a majority of the mammalian stocks that appeared in Europe and North America during the Tertiary. But we know much of our less remote fossil ancestors. Evidences of their slowly advancing skill in the fashioning of weapons and implements, in the discovery of the bow and the uses of fire are innumerable, and their skeletal remains are found over a period estimated at from 250,000 to over a million years. We know at least two, perhaps three extinct genera of men and at least five distinct human species. All the existing races of man—white, black, red and yellow—belong to the single zoological species which we modestly call *Homo sapiens*. I should say that our knowledge of the exact stages between non-human ape-like animals and man is as complete as was the knowledge of the evolution of the horse

at the time of the founding of this university when Huxley lectured on the evolution of the horse. At the present rate of discovery (Piltdown man in 1911, Foxhall man in 1919 and Broken Hill man in 1920), another generation will not pass before the story is complete.

Before relating what we now know of this story, I should like to refer to how we arrive at estimates of age in this part of the geological column—estimates which are as exact as the earlier dates of what is called the historic period. During geologic time immediately preceding the present there is conclusive evidence of a mantle of ice spreading over northwestern Europe and northern North America. This was not a single episode but a long enduring succession of glacial stages and milder interglacial stages—some of which were much longer than the time that has elapsed since the last ice sheet shrunk away from the Baltic or from the valley of the St. Lawrence. Naturally the deposits and moraines of the last ice sheet are fresher and less disturbed than the similar traces of the earlier ice sheets. By counting the annual layers in the clays in the wake of the shrinking ice of the last glaciation, we can trace and date its gradual withdrawal from the plains of Germany across the Baltic to the Scandinavian uplands, and the more broken clay layers in the valleys of the Connecticut, Hudson and Champlain give the story for this country. Using this period of time as a unit, we calculate from a variety of criteria the duration of the earlier glacial and interglacial stages. The oldest known man-like animal comes from distant Java and dates from the beginning of the Pleistocene, or from 250,000 to 1,000,000 years ago, or more precisely, twenty-five times as long ago as the interval since the last ice sheet extended across Long and Staten Islands here in the eastern United States. Evidence of human, or if you prefer so to call it, pre-human, industry in the form of rudely chipped flints and a knowledge of fire occur still earlier, and if the recent discovery of the Foxhall man in East Anglia is properly dated, we shall have unmistakable evidence of man in the late Pliocene. Our knowledge of the ape man of Java is on a sounder footing. First of all, he came from Asia along with the greater part of the considerable variety of animals and plants that are found fossil with him. The motive power was the less hospitable climates in Asia resulting from the gradual uplifting of its great mountain areas in the late Tertiary. The fauna and flora including the ape man drifted to the southeast down the broad valleys that at that time of emergence made a single land mass of the Malayan region. The anatomical features of the ape man are technical. Our interest centers on the brain case and the fact that

he was a ground inhabiting biped and not arboreal. The cranial capacity has been variously estimated between 850 and 950 cc as compared with 1,300 to 1,700 of the Neanderthal man of the third Interglacial period, or 650 cc, the greatest ape brain in the gorilla, which has twice the body weight of a man. The lower frontal-lobe region of this brain case shows conclusively that Pithecanthropus possessed speech—not sounds or signals expressive of emotional states, but that he was capable of transmitting ideas and information. In the painstaking models of McGregor, he has managed to superimpose on the obvious inheritance of the brute a look of fleeting intelligence and a dumb prophetic gaze that gives promise of the great things of the then far off future, and I confess to feeling a more tremendous thrill in the contemplation of that empty brain case than any other fossil has invoked.

A long gap in the record brings us to Sussex, England, and Eoanthropus or Dawn man of Piltdown. Discovered in 1911 the usual ignorance resulted in the destruction of most of the skeleton, as it did also in the wonderfully interesting find in the Broken Hill Mine of Rhodesia, so that only a few fragments of skull, 3 teeth, and a portion of the jaw were saved. Subsequently more fragments of other individuals have rewarded the most patient and painstaking search. If there is a wise Providence overhanging the world it is certainly watching over the paleontologists instead of their critics, which is rather surprising if paleontologists are as bad as they are sometimes painted, for these later finds are exactly the pieces needed to supplement the earlier, and to justify Smith Woodward's conclusions. The Piltdown man probably lived during the long and warm second Interglacial period. With him are found very primitive worked flints of the type known as pre-Chellean, together with bones of the rhinoceros, hippopotamus, beaver and deer. The skull is about twice as thick as a modern and 50 per cent. thicker than a Neanderthal skull. Its capacity was about 1,300cc. The jaws are protruding, the chin receding, the nose flattened and the canine teeth very prominent; in fact, although the skull and brain are essentially human and denote the power of speech, the jaws and teeth are much like those of a young chimpanzee, as are certain muscular attachments of the neck and temporal regions.

About the same age as the Piltdown man is the so-called Heidelberg man, based on a single jaw found in 1907 associated with a large fauna at the base of the Mauer sands, 79 feet below the surface. This jaw is exceedingly massive with receding chin, but human dentition, and is generally regarded as merely an extinct species *Homo heidelbergensis,* although some students would erect a distinct genus, Paleonthropus, for its reception. It seems clearly

to foreshadow the Neanderthal race of the third Interglacial period. Passing over implements representing the evolution of human industry and confining our attention to actual human bones, we must now jump from the time of the Piltdown and Heidelberg men over a blank interval, estimated at from one to two hundred thousand years, to the Neanderthal race. I say race advisedly, because some hostile critics have waxed humorous or satirical over the type skull-cap found in the Neander valley near Düsseldorf, as if that were the whole story. The earliest find of this race was a female skull found at Gibraltar in a cave in 1848, but the significance of which was not recognized until 1887. The Neander skull-cap with thigh bones and other fragments was discovered in 1856, and their description was received with indifference even by Darwin and Huxley, and it was not until a generation later, when two complete skeletons were found at Spy near Dinant in Belgium, 1887, that recognition of their significance became general. The appearance of this race in western Europe was contemporaneous with the wane of the last warm forest and meadow fauna of the Pleistocene and with the invasion of animals heralding the approach of the fourth glaciation. Hence the Neanderthal race dwelt in caves. Wells writes picturesquely, but not especially accurately, of their jackal-like habits, but the Neanderthalers were hardy, and appear to have utilized the bison, wild cattle, horse and deer for food, ousting cave bear and cave hyenas—the successive layers in the caves often tell an eloquent story of the struggles between man and beast for possession. Fire played its part and old hearths are abundantly preserved. Spears and throwing stones appear to have been the weapons used. The abundance of skeletons of this race is due to their cave habit and hence their better chance for preservation. Over an interval of something like 50,000 years, if not much longer, preceding Neanderthal times, we have abundant evidence of human industry in the pre-Chellean and Chellean cultures represented by flint implements, but these open-air nomads either threw their dead to the hyenas or buried them in the river terraces on which they dwelt, where the chances of preservation and fossilization were remote.

Homo neanderthalensis, primigenius or *mousteriensis* as it has been called, has been discovered at over twenty different localities. Skeletons of men, women and children and of many individuals have been collected, so that the earlier critics of the type material who pronounced them merely pathological, *i. e.*, a diseased modern man, are completely and absolutely refuted. In many of their important features this race was more ape-like than human, but their teeth were decidedly human; they possessed the power of speech,

fashioned skins and weapons, were skilled in the use of fire, and practised ceremonial burial, placing implements with their dead, the first appearance in the geological record of a belief in a future existence, so that we can not cut them off from us and say they were apes and not men. Let us get a good picture of this race that lived in Europe longer than have the Anglo-Saxons. They were short and thickset—the tallest skeleton indicates a height of 5 feet, 5½ inches; with very broad shoulders and muscular robust torso, big hands, short fingers, and not entirely perfected thumb joints. They were clumsy on foot, with ape-like legs, in that the shin is relatively short and the thigh long (shin 76 per cent. of thigh). Their knees were habitually bent, and they were squatters instead of sitters when resting or working, as shown by the facets on the ankle bone (astragulus). The forearm was relatively short, like the modern Eskimos, Lapps and Bushmen. That they were far removed from contemporary apes is shown by their arms being but 68 per cent. the length of their legs. In apes the reverse prevails—the chimpanzee's arm is 104 per cent. the leg length. The position of the foramen magnum, and the neck vertebra indicate stooped shoulders with the head held well forward, and a spinal column curved like that of a modern baby. The head was massive, with deep face, retreating forehead from heavy overhanging brows (platycephalic), with broad flat nose, long upper lip, prognathous jaws and receding chin. The skull was thick, but capacious. The jaw was similar to, but less massive than, that of the Heidelberg man of the second Interglacial. Let me point out that if you should find a modern skull with some of the ape-like features of the Neanderthal skull, it would prove nothing. Some of these ape-like features do occur in recent rare individuals of the lower races—they are all present in the Neanderthal skulls that have been discovered. I have said that the skull was capacious—the limits of variation are 1,300 to 1,700 cc (existing man, 950 to 2,020 cc). The size of the Neanderthal brain was therefore entirely human, but I need not emphasize that a large head does not necessarily offer anything except a field for tonsorial art, and what critics fail to take into account is that the Neanderthal brain, although it had quantity, lacked quality—its proportions were decidedly different from a modern brain—those parts concerned with the higher faculties were less developed and with simpler convolutions—this is not inference, but is based on the actual configuration of the interior of the brain case (we even know that they were right-handed). Over 50 sites of Neanderthal industry are known in western Europe (see map) and their implements increased in variety and improved in technique as the years passed, but not to any remarkable degree.

Some anthropologists hold that the Neanderthal race is represented by the Brünn and Piedmont races of the upper Paleolithic, others that they were exterminated by the arrival in western Europe of a new race from Asia about 25,000 years ago. This progressive race of *Homo sapiens*, the same species as ourselves, appears to have come from Asia Minor through Tunis into Spain, and perhaps along the northern shores of the Mediterranean as well. Their successive cultures are known as the Aurignacian, Solutrian, Magdalenian and Azilian, and the development of their industry and art has been traced with the most detailed precision. They were hunters, and followed in the trail of the wild ass, Elasmothere, steppe horse and various other Asiatic immigrants. Associated with fourteen Cro Magnons skeletons in the Grotto on the Riviera near Mentone are two negroid skeletons. (I will not stop to describe this negroid Grimaldi type.) The fourth Glacial period had not yet closed when the Cro-Magnons apeared in Europe, but the climate was dryer—the summer temperate, but the winters severe. Most of the stations where their remains have been discovered were in caves or rock shelters, but several open camps have been discovered, as at Solutré which was probably a summer assembling of hunters. This remarkable race was tall, the average height 6 ft. 1½ inches, with large chest, relatively long legs, remarkable lengthening of the forearm and shin, wide short face, prominent cheek bones, narrow pointed chin, narrow skull, aquiline nose and shallow orbits. They were vigorous and fleet-footed, practiced ceremonial burial, had much improved implements including the bow and arrow and stone lamps, with brains 1,500 to 1,880 cc. They show an appreciation of animals and have been called the Greeks of the old stone age because of their art, which included drawing, engraving, paintings and bas reliefs on cavern walls and floors, and the carving of soapstone, bone and ivory. Their history shows fluctuations in art and industry, in particular their flint workmanship declined with the introduction of bone implements. During the climatic fluctuations concerned with the oscillations of the shrinking glaciers and concomitant geographic changes, both their culture and physical vigor show a decline. Their history covers a period of from 10,000 to 15,000 years, and during this time there probably was some intermixture of other blood. Disharmonic skulls, *i. e.*, broad face and narrow skull, are still found in the Dordogne and at a few other localities and near by is the primitive agglutinative language of the Basques. Some conclude that these represent late survivals of the Cro-Magnon race. They were followed by fishing races and the first broad headed types, the Maglemose culture (possibly Teutonic) around the Baltic, the Mediterranean (known as the Tardenoisian), and

the Alpine (Furfooz Grenelle) along the Danube (painted pebbles). This was from 7,000 to 10,000 years ago, and the so-called Campignian culture of this time is transitional to the Neolithic or New Stone Age of polished stone.

The rest of the history belongs more to Anthropology and Archeology. The Robenhausian culture of the Swiss and other lake dwellings about 7000 B. C. shows permanent dwellings, domestication of animals and cultivation of crops with use of pottery; the Copper Age extended from 3000 to 2000 B. C.; the Bronze Age in Europe from about 2000 to 1000 B. C., in Orient 4000 to 1800 B. C.; the Iron Age (earlier or Hallstatt culture) in Europe from 1000 to 500 B. C., in the Orient from 1800 to 1000; and the latter Iron Age from 500 B. C. to Roman times in Europe.[1]

Note the cumulative rapidity of the advance as compared with slowness of change in earlier stages.

Although very much remains to be discovered we know enough to assure the layman that man has had a long evolutionary history extending over tens if not hundreds of thousands of years. Does this knowledge breed cynicism and irresponsibility. What answer does science give on this point? Since late Paleolithic time, *i. e.*, toward the close of the Old Stone age, 25,000 years ago, man's evolution biologically has been slight and to some extent retrograde. Skull bones and teeth have changed but little. It was during this period of slight physical change that our race has made the most astonishing progress, and the hope is natural that there is no limit to the betterment of the race by the exercise of wisdom, altruism and idealism—the spiritual graces if you choose so to call them.

[1] Figures from Obermaier.

SOCIAL LIFE AMONG THE INSECTS[1]

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Lecture II. Part 2. Wasps Solitary and Social

Authorities on the classification of the social wasps now divide them into five subfamilies, namely the Stenogastrinæ, which are confined to the Indomalayan and Australian Regions, the Ropalidiinæ, confined to the tropics of the Old World, the Polistinæ, which are cosmopolitan, the Epiponinæ, possibly comprising two independent lines of descent from Eumenes-like and Odynerus-like ancestors respectively and constituting a large group, mostly confined to tropical America, with a few species in the Ethiopian, Endomalayan, Australian and North American regions, and the Vespinæ, which are recorded from all the continents except South America and the greater portion of Africa south of the Sahara. These five families may be briefly characterized before considering some of the peculiarities of social organization common to most or all of them.

(1). The Stenogastrinæ evidently represent a group of great interest, because they form a transition from the solitary to the social wasps, but unfortunately our knowledge of their habits is very incomplete. F. X. Williams has recently published observations on four Philippine species, and though his account is fragmentary, it nevertheless reveals some peculiar conditions. He shows that the single genus of the subfamily, Stenogaster, includes both solitary and social forms and that all of them exhibit a mixture of primitive and specialized traits. The species all live in dark, shady forests and make very delicate, fragile nests with particles of decayed wood or earth. *S. depressigaster* (Figs. 30 E and F) hangs its long, slender, cylindrical nests to a pendent hair-like fungus or fern. The structure consists of tubular, intertwined galleries and cells, with their openings directed downwards. The colony comprises only a few individuals probably the mother wasp and her recently emerged daughters. The eggs are attached to the bottoms of the cells as in all social wasps and the larvæ are fed from day to day with a gelatinous paste, which Williams believes may be of vegetable origin. In the cells the older larvæ and the pupæ hang head downwards. Another social species, *S. vari-*

[1] Lowell Lectures.

pictus, constructs a very different nest, consisting of cells made of sandy mud mixed perhaps with particles of decayed wood and attached side by side in groups to the surfaces of rocks and tree-trunks (Fig. 30 G). In this case also the cell-openings are directed downward. A nest may consist of thirty or more cells in several

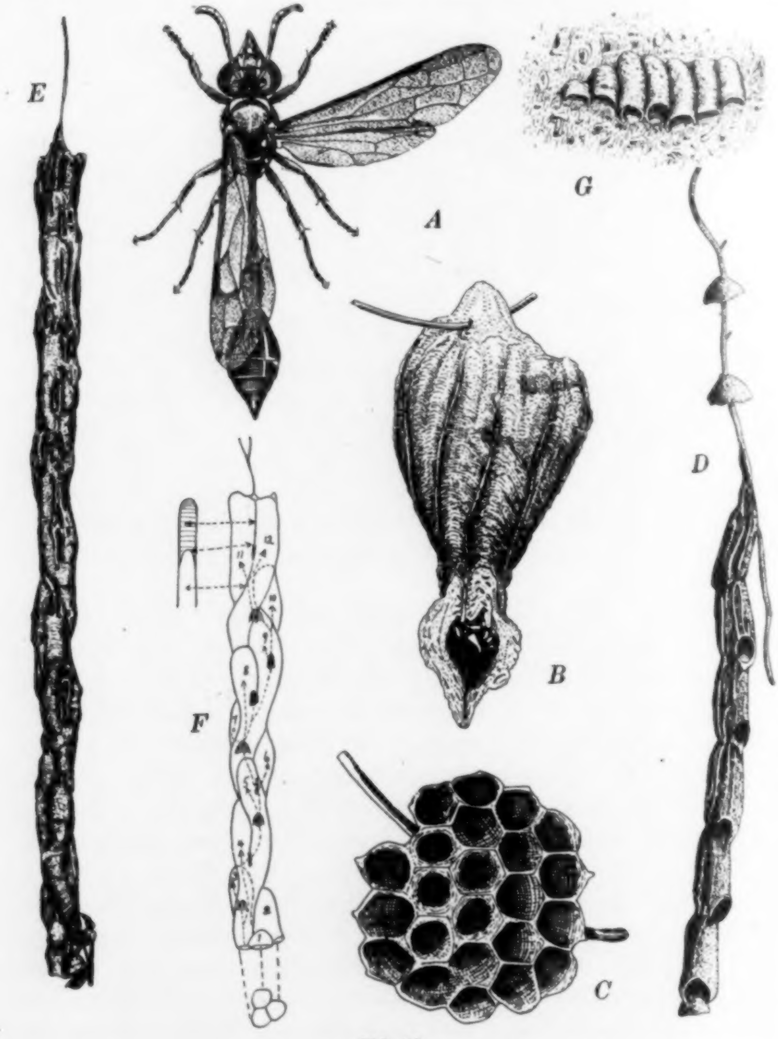

FIG. 30
Nests of Stenogastrine wasps from the Philippines. *A. Stenogaster micans* var. *luzonensis*, female. *B.* Completed nest of same; *C.* Nest with only the basal portion completed; *D.* Nest of *Stenogaster* sp., with umbrella-like "guards"; *E.* Nest of *S. depressigaster; F.* diagram of same showing arrangement of cells and passage-ways. The numbers indicate the cells. The tops of the passage-ways are shown in two planes by series of parallel lines. *G.* Nest of *S. varipictus* on the bark of a tree. (After F. X. Williams).

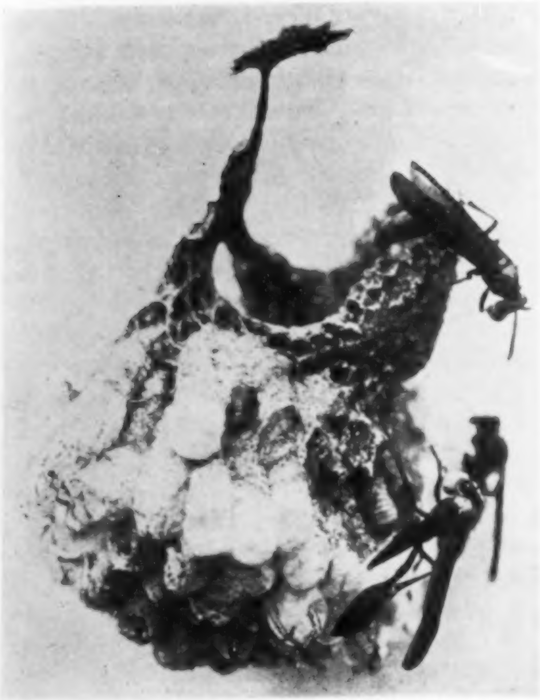

FIG. 31
Suspended and naked comb of a very primitive African Epiponine wasp, *Belonogaster junceus,* with young cells above and old cells containing larvæ below; natural size. Most of the wasps have been removed but two are seen bringing food-pellets to the larvæ. (Photograph by E. Roubaud).

rows. There are only a few wasps in a colony, and when the larvæ are full-grown the cells are sealed up by the mother as in the solitary wasps. But after the young have emerged the cells may be used again as in many of the social species. Williams describes and figures the nests of two solitary species, one an undetermined form, the other identified as *S. micans* var. *luzonensis*. The nest of the former (Fig. 30 D) is suspended, like that of *depressigaster*, from some thin vegetable fibre and appears to consist of particles of decayed wood. It is a beautiful, elongate structure of seven tubular, ribbed cells, arranged in a zigzag series with their openings below and two peculiar umbrella-like discs around the supporting fibre. These discs "remind one a good deal of the metal plates fastened to the mooring lines of vessels and serving as rat guards. Their function in the case of the nest may be an imperfect protection from the ants, or perhaps they may serve as umbrellas, though neither they nor the cells are strictly rain proof." They may possibly be rudiments of the nest envelopes which are so elaborately

developed in many of the higher social wasps. The mother wasp attends to several young simultaneously, and when their development is completed seals up the cells. *S. micans* var *luzonensis* (Fig. 30 B) makes the most remarkable nest of all. It is attached to some pendent plant filament under an overhanging bank or under masses of dead leaves supported by twigs or vines and is made of "moist and well-decayed wood chewed up into a pulp and formed into delicate paper which is not rain proof." The basal portion of the nest (Fig. 30 C) is a single comb of about 20 regular, hexagonal cells, enclosed in a pear-shaped covering which is longitudinally grooved and ribbed on the outside and constricted below to form a filigree-work, funnel-like aperture surrounded on one side by a spear-shaped expansion. This species seems also to have been observed in Ceylon by E. E. Green, who remarks that "the nest seems to be the property of one pair only" of wasps. Two other species, *S. nigrifrons* of Burma and *melleyi* of Java, are also recorded as social. They make nests consisting of a few pendent, hexagonal-celled combs attached to one another by slender pedicels. All of the descriptions indicate that the colonies of the social species of Stenogaster must consist of very few individuals, and there is nothing to show that the female offspring

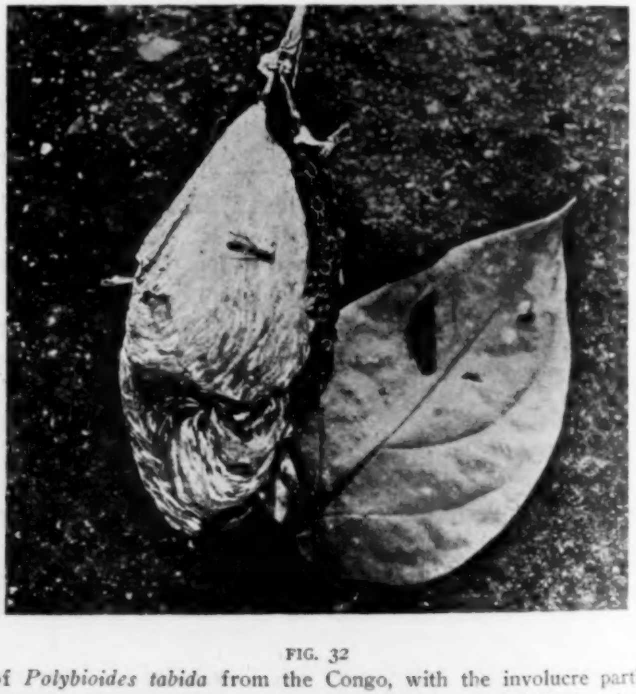

FIG. 32
Nest of *Polybioides tabida* from the Congo, with the involucre partly removed. (After J. Bequaert from a photograph by H. O. Lang).

differ in any way from their mother or that they assist in caring for the brood. Even in the case of *S. varipictus*, Williams remarks: "In a small way, it seems to be a social wasp; one to several insects

FIG. 33
A. Nest of *Polybioides melaena* of the Congo. *B.* The same partly destroyed, showing the pendent combs, which have cells on both sides. (After J. Bequaert, from a photograph by H. O. Lang).

attend to a cell group. It may be, however, that each female has her own lot of cells in this cell group." Future investigations may show that none of the species of Stenogaster is really social in the same sense as are the four other subfamilies, though they approach the definitively social forms in using paper in the construction of the nest, in sometimes making combs of regular hexagonal cells and in caring for a number of larvæ at the same time.

(2). The Epiponinæ are a large and heterogeneous group, comprising a much greater number of genera (23) than any other subfamily of social wasps, and ranging all the way from very primitive forms like Belonogaster to highly specialized forms like Chartergus and Nectarina. Great differences are also apparent in the architecture of the nest, which in the more primitive genera consists of a single naked comb of hexagonal cells attached to some support by a peduncle (Fig. 31), and in the more advanced forms of a single comb or of several combs superimposed on one another and enclosed in an envelope with an opening for ingress and egress (Figs. 32 and 33). The combs are in some cases pedunculate (stelocyttarous), in others attached directly to the support or to the envelope (phragmocyttarous). In nearly all cases the nest is made entirely of paper, but in a few tropical American species some clay may be added. It is always above ground and attached to the branches or leaves of trees, to the underside of some shelter (roofs, banks, etc.). In primitive forms like Belonogaster (Fig. 31), as a rule, a single fecundated female starts the nest by building a single pedunculate cell and then gradually adding others in circles concentrically to its periphery as the comb grows, but not infrequently the foundress may be joined by other females before the work has progressed very far. Each larva is fed with pellets of malaxated caterpillars till it is full grown when it spins a convex cap over the orifice of its cell and pupates. The emerging females are all like the mother in possessing well-developed ovaries and in being capable of fecundation. In other words, all the females of the colony are physiologically equal, and even such differences in stature as they may exhibit have no relation to fertility. The colonies are small, the nests having usually only about 50 to 60 cells, rarely as many as 200 to 300. In larger colonies there is a certain rude division of labor since the older females devote themselves to egg-laying, the younger to foraging for food and nest materials and the recently emerged individuals to feeding the larvæ and caring for the nest. The males, too, remain on the comb, but behave like parasites and exact food whenever it is brought in by the foraging females. Belonogaster is described as a polygynous wasp because each of its colonies contains a number

of fecundated females. When it has reached its full development the females leave in small companies and found new nests either singly or together. This phenomenon is known as "swarming" and occurs only in the wasps of the tropics where it seems to be an adaptation to the favorable climatic conditions. In the higher South American genera of Epiponinæ, however, the females are not all alike but are differentiated into true females, or queens, *i. e.*, individuals with well-developed ovaries and capable of fecundation, and workers, *i. e.*, females with imperfectly developed ovaries and therefore sterile or capable only of laying unfertilized, male-producing eggs. Many of these wasps, according to H. and R. von Ihering and Ducke, are polygynous and regularly form new colonies and nests by sending off swarms of workers with one or two dozen queens. The colonies often become extremely populous and comprise hundreds or even thousands of individuals. Some of the species (Nectarina, Polybia) have a habit of storing a considerable amount of honey in their combs, while others are known to capture, kill and store within the nest envelope, and even in the combs, quantities of male and female termites or male ants as a supply of food to be drawn on when needed.

(3). The Ropalidiinæ are a small group of only three genera, the best known of which is Ropalidia. These are primitive wasps which build a single naked comb like that of Belonogaster and feed their young with pellets of malaxated insects. The colonies are small and polygynous, but, according to Roubaud, true workers can be distinguished, though they are few in number compared with the true females. Swarming seems to occur in some species.

(4). The Polistinæ are represented by only two genera. One of these, Polistes, is cosmopolitan and, like Ropalidia and Belonogaster, makes a single, naked comb, suspended by a central or eccentric peduncle to the underside of some shelter. As there are several common species in Europe and the United States, the habits of the genus are well known. The nest is usually established and in its incipient stages constructed by a single female, or queen. A certain number of her offspring are workers though they seem often to lay male-producing eggs. True females are rather numerous in the colonies of some species, which may therefore be regarded as polygynous, and some of the tropical forms may, perhaps, swarm. In temperate regions, however, the Polistes colony is an annual development and usually not very populous. The young females are fecundated in the late summer and pass the winter hidden away under bark or in the crevices of walls, whence they emerge in the spring to found new colonies. Several of the species, even in temperate regions, are known to store small quantities of honey in their combs.

(5). Like the Polistinæ, the subfamily Vespinæ includes only two genera, Vespa and Provespa. The species of the former, the only genus besides Polistes that occurs in the north temperate zone, are the largest and most typical of social wasps. So far as known the species are strictly monogynous. The nest, founded by a single female, consists at first of a small pendent comb, like that of Polistes, but while there are still only a few cells a more or less spherical envelope is built around it. The eggs first laid produce workers, which are much smaller than the mother and incapable of fecundation. They remain with the parent, enlarge the comb and envelope and, to accommodate the rapidly increasing brood, build additional combs in a series from above downward, each new comb being supported by one or more peduncles attached to the comb above it (stelocyttarous). At first large numbers of workers are produced, but later in the summer males and females appear. Owing to the greater size of the females, the cells in which they are reared are considerably larger than the worker cells. After the mating of the males and females the colony perishes, with the exception of the fecundated females, which hibernate like the females of Polistes and during the following spring found new colonies. In the Vespinæ, therefore, a very distinct worker caste has been developed, though its members occasionally and perhaps regularly lay male-producing eggs. The species of Vespa are usually divided into two groups, one with long, the other with very short cheeks. In Europe and North America the long-cheeked forms as a rule build aerial nests above ground, the short-cheeked forms in cavities which they excavate in the ground. The colonies may often be very populous by the end of the summer (3,000 to 5,000 individuals).

After this hasty sketch of the five subfamilies of the social wasps we may consider a few of their fundamental behavioristic peculiarities, especially the trophic relations between the adults and larvæ, the origin of the worker caste, its ultimate fate in certain parasitic species and the question of monogyny and polygyny. In all these phenomena we are concerned with effects of the food-supply and therefore of the external environment.

The feeding of the larvæ by Vespa and Polistes queens and workers with pellets made of malaxated portions of caterpillars, flies or other insects has often been described and can be readily witnessed in any colony kept in the laboratory. The hungry larvæ protrude their heads with open mouths from the orifices of the cells, like so many nestling birds, and when very hungry may actually scratch on the walls of the cells to attract the attention of the workers or their nurses. The feeding is not, however, a one-sided

affair, since closer observation shows that the wasp larva emits from its mouth drops of sweet saliva which are eagerly imbibed by the nurses. This behavior of the larvæ has been observed in all four subfamilies of the higher wasps by du Buysson, Janet and Roubaud. Du Buysson says that the larvæ of Vespa "secrete from the mouth an abundant liquid. When they are touched the liquid is seen to trickle out. The queen, the workers and the males are very eager for the secretion. They know how to excite the offspring in such a way as to make them furnish the beverage." And Janet was able to prove that the secretion is a product of the salivary or spinning glands and that it flows from an opening at the base of the lower lip. "This product," he says, "is often imbibed by the imagines, especially by the just emerged workers and by the males, which in order to obtain it, gently bite the head of the larva." Most attention has been bestowed on this reciprocal feeding by Roubaud, from whose interesting account of Belonogaster, Ropalidia and Polistes I take the following paragraphs:

"All the larvæ from birth secrete from a projection of the hypopharynx, on the interior surface of the buccal funnel, an abundant salivary liquid, which at the slightest touch spreads over the mouth in a drop. All the adult wasps, males as well as females, are extremely eager for this salivary secretion, the taste of which is slightly sugary. It is easy to observe, especially in Belonogaster, the insistent demand for this larval product and the tactics employed to provoke its secretion.

"As soon as a nurse wasp has distributed her food pellet among the various larvæ, she advances with rapidly vibrating wings to the opening of each cell containing a larva in order to imbibe the salivary drop that flows abundantly from its mouth. The method employed to elicit the secretion is very easily observed. The wing vibrations of the nurse serve as a signal to the larva, which, in order to receive the food, protrudes its head from the orifice of the cell. This simple movement is often accompanied by an immediate flow of saliva. But if the secretion does not appear the wasp seizes the larva's head in her mandibles, draws it toward her and then suddenly jams it back into the cell, into which she then thrusts her head. These movements, involving as they do a stimulation of the borders of the mouth of the larva, compel it to secrete its salivary liquid.

"One may see the females pass back and forth three or four times in front of a lot of larvæ to which they have given nutriment, in order to imbibe the secretion. The insistence with which they perform this operation is such that there is a flagrant disproportion between the quantity of nourishment distributed among the larvæ

by the females and that of the salivary liquid which they receive in return. There is therefore actual exploitation of the larvæ by the nurses.

"The salivary secretion may even be demanded from the larva without a compensatory gift of nourishment, both by the females that have just emerged and by the males during their sojourn in the nest. The latter employ the same tactics as the females in compelling the larvæ to yield their secretion. They demand it especially after they have malaxated an alimentary pellet for themselves, so that there is then no reciprocal exchange of nutritive material.

"It is easy to provoke the secretion of the larvæ artificially. Merely touching the borders of the mouth will bring it about. The forward movement of the larvæ at the cell entrance, causing them to protrude their mouths to receive the food pellet, is also easily induced by vibrations of the air in the neighborhood of the nest. It is only necessary to whistle loudly or emit shrill sounds near a nest of Belonogaster to see all the larvæ protrude their heads to the orifice of the cells. Now it is precisely the vibrations of the air created by the rapid agitation of the bodies of the wasps and repeated beating of their wings that call forth these movements, either at the moment when food is brought or for the purpose of obtaining the buccal secretion which is so eagerly solicited."

Roubaud has called the interchange of food here described "oecotrophobiosis," but for reasons which I cannot stop to discuss, I prefer to use the word "trophallaxis." It will be seen that the larvæ have acquired a very definite meaning for the adult wasps of all the castes and that through trophallaxis very close physiological bonds have been established, which serve to unite all the members of the colony, just as the nutritive blood stream in our bodies binds all the component cells and tissues together. We found that even in forms like *Synagris cornuta* the larva has acquired a meaning for the mother. In this case Roubaud has shown that the mother while malaxating the food-pellet herself imbibes its juices before feeding it to the larva, and that "the internal liquids having partly disappeared during the process of malaxation, the prey is no longer, as it was in the beginning, soft and juicy and full of nutriment for the larva. It is possible, in fact, to observe that the caterpillar *pâté* provided by the *Synagris cornuta* is a coarse paste which has partly lost its liquid constituents. There is no exaggeration in stating that such food would induce in larvæ thus nourished an increase of the salivary secretion in order to compensate for the absence of the liquid in the prey and facilitate its digestion." It is here that the further development to the condition

seen in Belonogaster and other social wasps sets in. The mother finds the saliva of the larva agreeable and a trophallactic relationship is established. As Roubaud says, "the nursing instinct having evolved in the manner here described in the Eumenids, the wasps acquire contact with the buccal secretion of the larva, become acquainted with it and seek to provoke it. Thence naturally follows a tendency to increase the number of larvæ to be reared simultaneously in order at the same time to satisfy the urgency of oviposition and to profit by the greater abundance of the secretion of the larvæ."

As I shall endeavor to show in my account of the ants and termites, trophallaxis is of very general significance in the social life of insects. It seems also to have an important bearing on the development of the worker caste. Both queens and workers arise from fertilized eggs, and the differences between them are commonly attributed to the different amounts of food they are given as larvæ. There seems to be much to support this view in the social wasps. As Roubaud points out in the passages quoted, the larvæ are actually exploited by the adult wasps to the extent of being compelled to furnish them with considerable quantities of salivary secretion, often out of all proportion to the amount of solid food which they receive in return. Owing to this expenditure of substance and the number of larvæ which are reared simultaneously, especially during the earlier stages of colony formation, they are inadequately nourished and have to pupate as rather small individuals, with poorly developed ovaries. Such individuals therefore become workers. This inhibition of ovarial development, which has been called "alimentary castration," is maintained during the adult life of most workers by the exigencies of the nursing instincts. The workers have to complete and care for the nest, forage for food and distribute most of it among their larval sisters. All this exhausting labor on slender rations tends to keep them sterile. In other words, "nutricial castration" (derived from *nutrix, a nurse*, to use Marchal's terms, takes the place in the adult worker of the alimentary castration to which it was subjected during its larval period. It is only later in the development of the colony, when the number of workers and consequently also the amount of food brought in have considerably increased, and the labor of foraging and nest construction have correspondingly decreased for the individual worker, that the larvæ can be more copiously fed and develop as fertile females, or queens. At that season, too, some of the workers may develop their ovaries, but as the members of the worker caste are incapable of fecundation, they can lay only male-producing eggs. That this is not the

whole explanation of the worker caste will appear when we come to consider the much more extreme conditions in the ants and termites, but it may suffice to explain the conditions in the social wasps and social bees.

Parasitism is another phenomenon which seems to indicate that a meager or insufficient diet is responsible for the development of the worker caste. Although parasitic species are much more numerous among the bees and ants, I will stop to consider very briefly a few of those known to occur among the wasps. A parasite is, of course, an organism that is able to secure abundant nourishment for itself or its offspring by appropriating the food-supply that has been laboriously stored or assimilated by some other organism. The various parasitic solitary wasps, such as the species of Ceropales, among the spider-storing Psammocharidæ, all substitute their own young for the young of their hosts in order that the larvæ may come into undisputed possession of the stored provisions. Among the social wasps there are only two parasitic species, *Vespa austriaca* and *V. arctica.* The former has long been known in Europe where it lives in the nests of *V. rufa.* Recently Bequaert and Sladen have found *austriaca* in the United States, British America and Alaska, but its Cisatlantic host is still unknown, though believed to be *V. consobrina.* *V. arctica*, as Fletcher, Taylor and I have demonstrated, lives in the nests of our common yellow jacket (*V. diabolica*). Now both *austriaca* and *arctica* have completely lost the worker caste so that they are represented only by males and fertile females. They were at one time undoubtedly nonparasitic like their present hosts, but are now reared and fed by the workers of the latter like their own more favored sexual forms. As a result of such nurture what were once independent social insects with two female forms have actually reverted to the status of solitary forms with only one type of female.

In conclusion the conditions of monogyny and polygyny in the higher social wasps may be briefly considered. It was shown that the Vespinæ and at least most of the Polistinæ are monogynous, their colonies being annual developments begun by a single fecundated queen, and that they perish at the end of the season, with the exception of the annual brood of queens, which after fecundation hibernate and start new colonies during the following spring. Many of the tropical Epiponinæ and Ropalidiinæ, however, are polygynous and the former often form large perennial colonies which from time to time send off swarms consisting of numerous fecundated females or of such females accompanied by workers to found new colonies. This behavior is evidently as perfect an adaptation to the continuously favorable food and temperature condi-

tion of the tropics as is that of Vespa and Polistes to the pronounced seasonal vicissitudes of the temperate regions. There has been a difference of opinion among the authorities as to whether monogyny or polygyny represents the more primitive phylogenetic stage among the social wasps. The great majority of these insects are tropical, and probably even Vespa and Polistes were originally inhabitants of warm regions and invaded temperate Eurasia and North America during postglacial times. The monogyny still exhibited by these wasps in the tropics may have been acquired there as an adaptation to the wet and dry seasons, and this adaptation may have enabled them the more easily to adjust themselves to the warm and cold seasons of more northern regions. H. and R. von Ihering and Roubaud may therefore be right in maintaining that polygyny is the more primitive condition. Their view is also supported by the fact that in the polygynous genera the worker caste is either still absent (Belonogaster) or very feebly developed and constitutes only a small percentage of the female personnel of the colony. We might, perhaps, say that our species of Vespa and Polistes each year produce a swarm of females and workers but that the advent of cold weather destroys the less resistant workers and permits only the dispersed queens to survive and hibernate till the following season.

We shall find precisely the same differences between monogyny and polygyny in the social bees of temperate and tropical regions, and somewhat analogous conditions among the ants, although their polygyny may be secondarily derived from monogyny. It would seem that swarming must be a phenomenon which occurs as a rule when the environment is unfavorable or the colony has grown to such dimensions as to outrun its food-supply so that emigration of portions of its population becomes imperative.

CHARLES DARWIN, THE MAN

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AT the present time, which marks the fortieth anniversary of the death of Charles Darwin (died April 19, 1882), an odd recrudescence of the old opposition to evolutionary thought in the less educated circles is challenging the attention of men of science in this country. But to us it seems much more appropriate to the anniversary to undertake to consider Darwin's personal traits, and especially such aspects of his character as bear upon his far-reaching influence upon men to-day.

Charles Robert Darwin was born in 1809 of a family in which a considerable variety of excellent mental attainments are to be found; a family in which, if we should try to note any single outstanding mental characteristic that found repeated expression, we should have to say that the most constant trait was a very highly developed curiosity. Robert Waring Darwin, his father, was a physician. He was neither scientific nor philosophical in the strict sense, as it is reported that he did not try to generalize his knowledge under general laws. Yet he formed a theory for almost everything which occurred. He is described as having an extraordinary memory for people, events and dates, as being an unusually shrewd judge of character, and also a cautious and good man of business. The grandfather, Erasmus Darwin, showed a speculative turn in his curiosity, and was the author of the afterwards famous Zoonomia. Among more distant relations and ancestors are men who gave their enthusiasm to such subjects as numismatics, statistics and various branches of natural history.

On the maternal side, Darwin had the possibility of inheriting the unusual ability in practical arts for which the Wedgewood family was noted. His mother died early, when the son was only eight years of age, and the published record of her tells little more than that she was of a most kindly and sympathetic nature.

Charles Darwin felt the very deepest of personal devotion to his father, and many of his own traits of character are a very natural development from the family atmosphere in which he was raised. This applies especially to his kindliness and ready appreciation of others, and his extreme modesty as regards his own opinions and

accomplishments. As regards traits that were needed for his future career, it was his opinion that he acquired little besides the love of observing.

School seems to have been of exceptionally slight benefit to the young scientist. In fact the comments upon his education that he makes in his reminiscences are in surprisingly similar tenor to the ironic undercurrent in Henry Adams's reminiscences of his education. He was not taught to observe, nor to think, nor to use the languages which he would need, nor to make serious use of mathematics. To the end of his formal education, his desire seems to have been little more than to escape, usually into the country in company with congenial hunting companions and nature lovers. Strangely enough, this applies even to his life for two years as a medical student in Edinburgh, where he apparently came under a group of lecturers who were uncommonly devoid of inspiration, so that he felt positively repelled even from geology and botany. On the other hand, he began there to make acquaintances who developed his inclination toward acute observation of nature. He names in this connection the zoologist, Grant, and several other young university men, a negro taxidermist, and some of the fisher folk at Newhaven.

As the young Darwin showed only distaste for the medical sciences as presented to him, a church career was proposed instead, and he brushed up on his rusty Greek, to gain admittance to Cambridge. It is interesting that among his studies he found algebra and the classics unutterably dull, but geometry delightful for its vivid and precise logic, and Paley's "Evidences" and "Natural Theology" similarly pleasing for its keen deductive reasoning.

But in the main he shunned his studies in Cambridge as consistently as he had in Edinburgh. He became a devotee of hunting and riding, and then later became deeply engrossed with collecting beetles. "No poet," he says, "ever felt more delighted at seeing his first poem published than I did at seeing in Stephens's Illustrations of British Insects the magic words 'captured by C. Darwin, Esq.' "

Here again, as it had been in Edinburgh, the most important aspect of his life came from the friendships which he formed. Especially noteworthy were his constant companionship with Henslow, the professor of botany, and toward the end of his stay, his acquaintance with Professor Sedgwick of geology.

"Looking back," he says, "I infer that there must have been something in me a little superior to the common run of youths, otherwise the above-mentioned men, so much older than I and higher in academic position, would never have allowed me to asso-

ciate with them. Certainly I was not aware of any such superiority."

Darwin's keen love of good logic and his passion for observation seem not to have been united in the same object in any of his activities in Cambridge, and the thought that they might conceivably be so united seems first to have been brought to him by a conversation with the geologist Sedgwick in the summer of 1831 (Life, p. 48): He told Sedgwick of a certain tropical volute shell that was supposed to have been found in an old gravel pit near Shrewsbury, England. "He at once said that it must have been thrown away by some one into the pit; but then added, if really embedded there it would be the greatest misfortune to geology, as it would overthrow all that we know about the superficial deposits of the Midland Counties. . . . I was . . . utterly astonished at Sedgwick not being delighted at so wonderful a fact as a tropical shell being found near the surface in the middle of England. Nothing before had ever made me thoroughly realize, though I had read various scientific books, that science consists in grouping facts so that general laws or conclusions may be drawn from them."

Darwin's appointment to H. M. S. *Beagle*, in 1831, when he was 22 years of age, was the beginning of his serious education. (Huxley, p. 271): "While at sea, he diligently collected, studied, and made copious notes upon the surface fauna. But with no previous training in dissection, hardly any power of drawing, and next to no knowledge of comparative anatomy, his occupation with work of this kind—notwithstanding all his zeal and industry—resulted for the most part in a vast accumulation of useless manuscript." It was in geology that his training first began to show fruit. He had with him the first volume of Lyell's "Principles of Geology," and this book seems to have had a greater influence upon his scientific methods than any other one factor.

In this book Lyell expounds by the inductive method the "uniformitarian" conception of geological history, which, unlike the cataclysmic theory which was then generally accepted, viewed the course of this history as controlled by the prolonged action of the very same forces that we can study at work to-day. The influence of this volume upon him was profound and manifold; so great indeed, that later when he had convinced himself of the doctrine of natural selection, it became his conscious ambition to present his theory to the public in a book modelled along the same logical lines as Lyell's great work. Under the guidance of this book he became a keen and systematic geological explorer, and he was able at the end of his voyage to present the world with three important monographs in that science, covering the coral islands, the volcanic

islands and the South American continental regions which he visited. It is interesting that he recommends geology to his cousin, W. D. Fox, telling him that in it "there is so much larger a field for thought than in the other branches of natural history;" also "Geology is a capital science to begin, as it requires nothing but a little reading, thinking and hammering." Evidently the instinct for generalization had at last got control over him.

From this date on, investigative science becomes more and more frankly his predominant interest, so that a year later (1836) he confesses about certain ports which he expected to visit "these will be a poor field for natural history, and without it I have lately discovered that the pleasure of seeing new places is as nothing."

When he returned to England in 1836, at the age of 27, his characteristics as a scientific man were fully formed. Thereafter the chief scientific events of his life are summed up in the development and publication of the great generalizations for which he will ever be remembered. So we can stop tracing his biography, and concern ourselves with his outstanding traits.

One of the traits which shows most vividly to the reader of Darwin's letters, and of his "Journal of the Voyage of the *Beagle*," is his keen ability to place his finger precisely upon the unsolved mysteries of contemporary science, and his apparently instinctive sense as to which of these mysteries ought to be capable of solution. It is obvious what a depth of intuition he showed, when he started, in 1837, a notebook on the nature and mutability of species and varieties in nature and under domestication. The related mystery of geographical distribution is most vividly handled in the "Voyage of the *Beagle*." As early as 1835 the discussion of an epidemic among the Maories gave him the occasion for a similarly clear expression of the scientific mystery of contagion. Thus his mind was perpetually setting him problems of the most fundamental nature, which he simply could not leave alone. His son quotes the characteristic remark which a new experimental idea would often bring from him: "I can't rest now, till I have tried it."

The problems to which he gave his time were always ones which were capable of approach by the methods of a naturalist, and the naturalist's methods were always his preference. Almost always he collected great masses of facts, the qualitative range of which usually occupied his attention much more than their quantitative mathematical analysis. His method did, however, lead him to gather facts in such quantities that it was only possible to master and present them by using the simpler form of statistical treatment, and he may almost be said to have introduced this method as a mental tool for naturalists.

As to the solutions to his problems, he confesses that only in the rarest instances did he have an inkling of the right clue, until after extensive data had been collected. He mentions only one important exception to this rule, and that is one of his earliest contributions to science, the theory of the formation of coral reefs. In all other important cases he started either without any hypothesis at all, or else with a tentative hypothesis that had later to be discarded.

It is small wonder that the unwritten history of his discarded hypotheses left him increasingly mistrustful of all elaborately deductive reasoning. For all deduction is based on the preliminary acceptance of a group of laws or hypotheses. In this respect he seems to us of to-day to contrast sharply with many of the characteristics of his own age, which was certainly much given to far-flung systems of speculative reasoning.

It is possible that some one may feel like challenging this statement that Darwin's speculations were not built into far-flung and elaborate systems like those of his leading contemporaries. But I believe that his methods in seeking a scientific solution of the problem of species fully justify the assertion. When he became dissatisfied with the orthodox doctrine of special creation, he did not turn at once to one of the doctrines of descent, several of which had already been propounded. Instead he insisted upon waiting to detect some process by which species are actually undergoing transformation at the present day and then he merely pointed out that within the vast extent of geological time there was room for this process to achieve results of the most startling magnitude.

Only in the one instance of his "Provisional Hypothesis of Pangenesis" he appears superficially to deviate from his preference to keep away from elaborate systems of theory. But he was himself most keenly alive to a difference in status between this provisional, unproved hypothesis which he brings forward as probably a helpful stimulus to the investigation of heredity, and the other theses he has defended, such as natural and sexual selection, which are to him scientific principles, the actual proofs of which are already substantially in hand. Had he taken the latter attitude toward Pangenesis, he would have been committing the typical intellectual sin of his era, and perhaps of many another era, of building great speculative structures upon slight foundations.

In the second place, in spite of certain intricacies in the details of the hypothesis, the speculative foundation of Pangenesis is not really intricate. It rests simply on two suppositions: (1) that all heredity is by continuity of substance, and (2) the now discarded supposition that every part in a many-celled animal begets the corresponding part in the offspring. It follows from these

two suppositions, that the gonad or the germ plasm would not be the seat of heredity, but merely its vehicle, receiving the fundamental active material agencies of heredity (the "gemmules") from every cell of the parental body, and packing them into the germ cell. Beyond this, all that Darwin has to say about the hypothetical gemmules is that if such is the basis of heredity, then various ascertained facts regarding the course of heredity indicate that the said gemmules must be assembled, and must become active or latent according to a certain set of rules. And that, in brief, is the whole of the "provisional hypothesis of Pangenesis."

Another aspect of Darwin's scientific temperament is his absolute candor and open-mindedness. We may note a delicious instance of this, which struck his own sense of humor. In 1856 Lyell and a great many of the world's best field naturalists were accounting for the distribution of plants and animals to the oceanic islands by the theory of continental extensions to include these islands. Darwin saw strong reasons to disbelieve this, at least as applied to mid-oceanic islands, and so was in friendly controversy on the subject for some time. But if he should win this controversy, think what difficulties he was preparing for his soon-to-be-published doctrine that structural relationship meant blood relationship between the insular and continental floras! So he spent endless pains in incubating the mud from ducks' feet, to learn what seeds birds might carry on their feet, and proving such pertinent facts as that grass seed, eaten by minnows, which in turn were eaten by storks, would be avoided by the storks in a fertile condition. Referring to one of these prospective tests, he exclaims, "This is an experiment after my own heart, with the chances 1,000 to 1 against its success!" And commenting at another time upon his whole dilemma of distribution he says, "There never was such a predicament as mine: here you continental extensionists would remove enormous difficulties opposed to me, and yet I cannot honestly admit the doctrine, and must therefore say so," and then adds, "Nothing is so vexatious to me, as so constantly finding myself drawing different conclusions from better judges than myself, from the same facts."

In his self-analysis, which forms a part of his brief autobiography, he remarks that he believes himself freer than the average man from the danger of reasoning by catch-phrases. Very characteristically he suggests that his lack of facility in expression may have helped guard him against such a fault.

Another virtue which we may just mention in passing is that for Darwin every sound scientific explanation must pin solidly to earth. The mysticism of such a naturalist as Agassiz was utterly

foreign to him, so that he could only remark that it was strange so brilliant a man should express such opinions.

Many things connected with his methods of work throw an interestsing light on his character. He declares himself that during his scientific career his industry has been nearly as great as it could have been in the observation and collection of facts. To compensate for the delays caused by ill health, he kept his work methodical to a very high degree. Because of the nature of his work, he gathered great quantities of material from other naturalists, observations which they had made with other considerations in mind. It is indicative of the scale on which he gathered data, that at the height of his work he had some 40 large portfolios of classified and indexed notes. His racks of notes may be seen in the picture of his study at Down (Life I, p. 101).

Whenever he broke loose from the routine of his schedule, he called it "idling;" for example, if the work in hand was geology, and he suspended it for a few days to carry out and experiment on one of his problems.

His instinct for an inherently sound and convincing presentation of the evidence seems to have endowed him with almost limitless patience. From the date when he first began organizing his thought on the problem of the Origin of Species, to the date of the first preliminary account of his conclusions, was a period of 21 years. When the book itself appeared, one year later still, its more than 400 close-printed pages were an abstract, at about one fourth size, of the intended work, which itself was but an abstract of his argument as he had massed it in his folios. This slowness came from thoroughness, scientific caution, and mistrust of his ability to persuade, probably far more than from the more superficial cause of ill health. Darwin speaks of the advantage that he often gained thereby, in being able to criticize old chapters objectively before ever submitting them to publication.

In his correspondence, and, it is stated, in his conversation, he showed much felicity of expression. But when he wrote in argument his style was undoubtedly liable to be clumsy.

"There seems," he says, "to be a sort of fatality in my mind, leading me to put at first my proposition in a wrong or awkward form." He conquered this difficulty to some degree by "scribbling in a vile hand whole pages as quickly as possible" and revising only at a later date.

Among his personal characteristics kindliness, modesty and frank appreciation of others are most conspicuous. His modesty has often been remarked upon, but to really appreciate how deliciously far it goes, one has to read his letters at first hand.

His freedom from the trammels of tradition and his keen sympathy for every form of misfortune probably account for his description of himself as a radically inclined liberal. His antislavery sentiments at all times, and particularly during the American Civil War, were very intense. A most odd expression of his humanitarian interest was his attitude toward Christian missions. He was most appreciative of the wonders that had been accomplished in Polynesia, but could not believe that peoples so low in the scale as the Fuegians and the Australian Blacks could possibly receive any benefit from mission work. He expressed this opinion freely, and when finally the reverse was proved in the case of the mission to Tierra del Fuego, he enthusiastically acknowledged his mistake, and expressed it in the form of a regular annual remittance of £5 to the cause of the mission.

He had a habit of writing his appreciations to the authors of books he had enjoyed, which we can understand if we consider how greatly he himself appreciated such letters written to him. He was also a man who very quickly treated men of a younger generation as his equals, or even his superiors in science, so that he was often a great inspiration to younger men.

In esthetics Darwin had a tremendous, and it might be said, a highly trained feeling for the beauties of nature. His deepest responses were to those scenes that expressed to his knowing eye some aspect of the wonderful cosmic drama.

The wastes of Patagonia and the sight of a naked savage in his native environment are two scenes which he speaks of as most strangely impressive, evidently through the story they tell him of *das ewige Werden*. He never forgot the sublimity of the Cordillera or the lavish luxuriance of the Brazilian forests. And we have his children's word to testify to the peculiar keenness of his appreciation of the precious, homely loveliness of his own England, which seemed hardly diminished, as nearly as any of them could tell, to the very end of his life.

In music, painting and literature, he had an essentially naïve and untrained, but for the most part fairly lively enjoyment. In his later years he lost his taste for the set, formal types of literature, so that verse, or the standard drama (like Shakespeare) no longer interested him. This seems to be the principal excuse, along with the quieter enthusiasms of old age, for his self-criticism as having atrophied on his esthetic side. Yet his family reports that even totally ignorant as he was of the slightest vestige of the principles of music, he always loved to listen, and his choice was uniformly for a good quality of music. So before taking too seriously his account of his esthetic atrophy, we really ought to view him a

little through the eyes of his children and friends, and then decide how much to discount his statements on the score of his peculiar modesty.

We are especially interested to-day in the contribution of Darwin to the spirit of science, and for that reason should like to consider his spirit as it were apart from the actual intellectual content of his additions to human knowledge. That is the more possible, as we can easily imagine that even without his aid the evolutionary hypothesis might have triumphed within a few decades of when it did actually triumph. The world had become accustomed to the idea of nature acting in strict accordance with law; to the concepts of stellar evolution, and of an inconceivably prolonged geological and paleontological history. It had even been recognized that such laws as the conservation of energy and the conservation of matter were valid in the kingdom of life. Goethe, Erasmus Darwin and Lamarck had long previously directed attention to the conception of an orderly derivation of the more complex types of life out of their less complex predecessors.

To be sure, no definite evolutionary theory had as yet won any great following among naturalists, because all of them up to that time had been either too vague or else too mystical to carry conviction. Lamarck's theory, which was most prominent because it had been the most fully elaborated, had a very strong mystical element. It was, broadly, to the effect that the offspring derived their physical constitutions not merely from the physical constitutions with which their parents had started life, but also from the additional development which the parents acquired through exercise and habit, and from a vast accumulation of "prenatal influences," if I may so express it, derived from the emotional life, and more especially from the desires, strivings and aspirations of the parents during their whole life previous to the act of generation.

Other defenders of evolution through descent usually either appealed to the same group of supposed influences, or emphasized one or another factor within this group (habit and exercise, for example), or appealed to an innate or divinely instilled tendency toward structural elaboration and self-perfection.

Immediately previous to Darwin's first public announcement of his natural selection theory, things were happening that indicated the readiness of a group of younger scientists to turn attention once more to an evolutionary conception. Herbert Spencer had already indicated his adherence to a modified form of the Lamarckian theory. Huxley, who had spurned the prenatal influences of Lamarck, was in private expressing at least an equal

degree of dissatisfaction with the orthodox theory of species as independently created entities. Von Baer, in Germany, was definitely of the opinion that some form of evolution through descent would have to be accepted. Finally came Wallace's paper, independently propounding the theory of natural selection, which as is so well known was read at a meeting of the Linnean Society jointly with a brief preliminary paper by Darwin, in the summer of 1858.

Suppose now that the great series of publications by Darwin had not come from his hands, in what ways would the world of science be poorer to-day? We can easily imagine that Wallace might have won Huxley, and have found Spencer a powerful ally. Huxley was not the type of man who could have rested till he had converted other scientists, and we can hardly doubt that this gifted debater, possibly aided by others of the young biological group, might gradually have compelled the scientific world to pay attention to the evolutionary hypothesis.

Without going into detail, the same situation held true of Germany, von Baer in particular being more than ready for any rational doctrine of descent.

If through these channels a great success had by any chance been achieved, the immediately following history would have been but little different from what it actually was. For in a sense Darwin was hardly at all an active participant in the dramatic contest that waged about his book. The giants of this battle were masters of debate, of repartee, of innuendo, such as Huxley and Wilberforce, and not at all the quiet, uncontentious, semi-invalid naturalist, who in his family circle applauded alike the brilliant thrusts and neat maneuvers of both groups of contestants. Darwin's supreme ambition had nothing whatever to do with the dust that was stirred up by his book; for it was simply to be able to thoroughly convert Huxley, the zoologist, Hooker, the botanist, and Lyell, the geologist. If many other scientists were also converted, that would seem to him a surfeit of success; and as for that group which obviously could never accept his argument, he was simply astonished that they took notice and reacted so quickly and so vigorously.

The fact, then, that the "Origin of Species" became at once the bone of contention between the great schools of thought did not give its writer any great immediate power to influence the spirit of the mid-nineteenth century, which became, in spite of him, and even by reason of his contribution, more and more exuberantly speculative. The mass of his contemporaries were akin less to him than to the temperament of Herbert Spencer, of

Haeckel, and of Weismann, with their elaborate theoretical systems.

During these exciting times, the man who had started it all was quietly at work upon a book descriptive of "The various contrivances by which orchids are fertilized by insects." Incidental bits of this study came out in 1860, 1861, and 1862, and the finished work in 1862. Such was Darwin's continual attitude toward controversy—not contemptuous but simply unworried, content to make use of whatever criticism was helpful, and to watch to improve the wording in the next edition wherever it appeared that his language was honestly misunderstood.

Only a very few of the adverse criticisms touched him where it hurt. One, for example, let it be understood that he wrote with an air of cock-sureness, a sin of which he could not bear even the shadow of suspicion. At another time Darwin bursts into righteous indignation on Huxley's behalf, when he catches a reviewer ascribing to Huxley a motive in his belief—Lyell's " 'object' to make man old, and Huxley's 'object' to degrade him. The wretched writer has not a glimpse of what the discovery of scientific truth means." Such was his spontaneous outburst at the least hint that scientific opinions might be motivated.

Darwinism was the signal for an overwhelming readjustment of popular metaphysics, as everybody knows, but it really seems hard to realize to-day how deeply men's minds were shaken, all through the thirty or forty years of the readjustment, by questions of purely abstract philosophy, or to what an extent the biological scientists have taken part in the philosophic questions. To make vivid the acuteness of that old situation, we may recall how Huxley, intensely loyal as he always was to the scientific concept of causation, nevertheless declared in substance (Romanes Lecture) that ethics was inexplicable, to the best of his understanding, from the standpoint of biological evolution; or again to the attitude of Wallace (Darwinism, Ch. XV) that the higher intellectual, esthetic and moral gifts of man are gratuities bestowed upon him by a benevolent deity through agencies entirely outside of the workings of biological evolution.

In all these abstruser corollaries of evolution Darwin took absolutely no part whatever, and even when questioned he did little more than plead ignorance and incompetence. Theism seemed to him a deduction flung too far afield to be dependable. He can not help doubting whether our brain equipment was ever designed for such uses. Nevertheless, he seems to have retained to the end of his days the simple rudiment of faith that "this universe is not the result of blind chance" ("Descent of Man," last pages;

"Life" I, 286), even though our intellects may not have the caliber to prove what else it is.

In all this, and especially in his freedom from intensity over such matters, he was hardly a type of his own era, and I can not help feeling that he is more at one with the complexion of thinking men of to-day—men to whom the evolutionary conception is as natural as it was to Darwin himself, so that they are no longer fussed by its possible metaphysical implications. Like him they still possess a philosophy of life, but one that is more proximate and less abstruse than what their nineteenth century predecessors were mostly wrestling with.

Is it not possible that the older generation of teachers to-day, the men who were brought up on Darwin as their daily bread, but who on account of the mental stresses of their era had to fight to attain and to defend the true Darwinian spirit of scientific candor —that these teachers to-day are finding in their pupils youths for whom a part of this victory has been won in advance, so that scientific candor, the spirit of unmotivated judgments, is for them an easier lesson than it was during the era of storm and stress in which the teachers had to learn it?

If this description is accurate, a substantial part of the credit must be ascribed to the slow-working leaven of the personality of Darwin himself, perpetuated in his writings and ramifying through the examples of those whose scientific ideals he has inspired.

THE MENTALITY AND THE COSMOLOGY OF CLAUDIUS GALEN

By JONATHAN WRIGHT, M.D.

THOSE who think of Galen at all, even those who have had some acquaintance with his writings, think of him as a physician, but a man can not be entirely a physician without being somewhat of a philosopher.[1] Hippocrates puts it a little differently and says no one can be so well a philosopher as he who seeks the truth in a study of medicine. I am not sure there is not much that one should ponder in this opinion. Such wisdom as one arrives at in regard to the moral and physical destiny of man as well as in regard to his environment is to be garnered most abundantly close to physiological and psychological fields. Now, singular to say, the things that are most lacking in the philosophy of Galen are the ethical values of humanity in their broader aspects. Man's narrower personal outlook constantly receives incidental mention as one goes through the vast sea of his professional writings. These are commonplaces of worldly wisdom, which he did not practice very successfully in some respects, owing to his glaring temperamental defects. Into all this I do not intend here to enter at all except to repeat that his philosophy in no way entitled him to boast the proud apothegm of Terence, *Nihil humanum mihi alienum est.* In so far as man himself is part of the cosmos in its intellectual and moral spheres, Galen's cosmical philosophy is negligible.

It is however with the ultimate structure of the universe that Galen's chief interests lie in cosmical philosophy. He is the heir and one of the chief sources of our historical knowledge of the strivings of the earliest Greek philosophers after a fundamental knowledge of natural phenomena. He was educated in a thorough régime of moral philosophy as taught by the various schools of his day; but, though he shows some traces of the teachings of the Stoics, it is the physical nature and structure of man alone he studies from the viewpoint of the Nature Philosophers. Doubtless in the shaping of the humoral doctrines for their final permanency in medicine, moral philosophy has little place, but the neglect of intellectual interests in certain directions perhaps had something

[1] *Galeni de optima secta ad Thrasybulum*, Liber I, 107. In these references I use the Kühn Latin translation, the Roman characters denoting the volume of that edition and the Arabic the page number.

to do with the oppressive narrowness and the absurdities into which he guided medical doctrines and where they remained for more than 1,500 years. Despite his formal piety he was a contentious upholder of positivism—a very mule's head in debate is the only contemporary notice we have of him. His admiration for Plato was but lip service so far as the practical workings of his mind are concerned. It is true he acknowledges that though our extended acquaintance with natural phenomena is acquired through the senses there is an innate knowledge, but how it works or to what it owes its existence is not so clear. A man knows when a line is straight and when it is crooked. "Of course with asses no one permits oneself to argue, for they have no minds, so also with men who have only minds in which they have no confidence."[2] There is no use of referring the uncertainty of knowledge to one who has no organ of knowledge, he viciously says, or does not believe he has.

To tell the skeptic he is not sure he thinks because he has nothing to think with may be witty enough, if one is in the mood for wit, but it is a flippant way to discuss problems of serious philosophical import. At best it is only one of the jokes of the ages revamped in every generation. In Plato the wit in the discussion plays no less around the subject, but it is less offensive and more subtile, more suggestive and instructive. The doctrine of Protagoras that man is the measure of all things is discussed more pleasantly, more profoundly, and the argument, unflinchingly nevertheless, faces the doctrine of eternal verities in the realm of ideas. Although I have elsewhere dwelt in dissent on the inclination to place the quality of Galen's mind in the category of that of Hippocrates or to rank it with that of Plato or of Aristotle, I allude to it again, for in studying his cosmic philosophy it becomes apparent that his contribution to it contains nothing original and his comments lack originality not alone because he lived in an age long since degenerated from that of the giants of Greek thought, but the quality of his mind was a handicap which even a favorable environment could not overcome. In a way his own gibe could be turned against himself. He did not have a suitable organ to do that kind of thinking with.

It would be an endless task to select from all his writings and summarize the incidental references marking his thought as to the nature and extent of the divisions of matter, but we have one treatise[3] in the form of a commentary on the ideas of Hippocrates as to its constitution which we can use as a guide to his cosmic philosophy in the sense I have defined it. He there takes up the

[2] *Galeni de optima doctrina*, Liber I, 40.
[3] *De elementis ex Hippocrate*, Liber I, 413.

cudgels in defence of the author of the "Nature of Man," in the Hippocratic Corpus. If we were to discuss here the philosophy of Hippocrates instead of that of Galen we should have to consider the question in some detail as to this book being the product of the mind of the man who wrote the best of the books of that collection. Galen from his own limitations saw no reason why it can not be placed among them. But modern critics with Littré at their head insist this can not be done even if we consider only the tenor of thought of the writer. While some of the doctrine in it seems evolved out of passages in the "Ancient Medicine," in the latter the author advances no such vulnerable argumentation on cosmic subjects as that Galen is at pains to defend. The manner in which he does this, rather than his adoption of the opinions there found, gives us an insight into his methods of thought. It can not be said that he always defers to the opinion of Hippocrates, perhaps, though I have never been reminded he was actually contradicting him, but it is quite apparent that he does violence to the text occasionally as well as to the meaning in reading some of his own convictions or rather his own preferences into the criticisms he reports Hippocrates makes of the opinions of others.

It is curious the disciple in his commentary should deduce from the master the argument for a plurality of elements which he stresses. Man would be devoid of feeling or sensibility, and his five senses would not function, if one only element was the material out of which man is compounded. They both fail to take into account the forces working on matter, a contribution made by Empedocles, though Galen was aware of them as he mentions them incidentally elsewhere, indeed makes much of innate dynamic influences in physiological action, drawn more or less directly from that ancient philosopher. The diversity of these in their potentiality for making contrasts, whereby things are perceived by the apposition of their contraries, apparently does not occur to him. It would seem that while the argument he emphasizes is prominent in the medical treatise he ascribes to Hippocrates, "The Nature of Man," it might be allowed to pass as the superficial argument of a writer who had specialized on medicine and was not concerned with ultimate cosmic doctrine. Whether it is a genuine treatise of the great Hippocrates or not, it is not one to which great weight can be attached. In the books now considered genuine, Hippocrates so far as I know makes no use of this argument. It follows from the terms of the doctrine of Democritus that his atoms, the ultimate divisions of matter, are devoid of qualities in themselves but give rise to the perception of sense only by means of the kind of impact they make on the animal structure. By the way in which Plato treats the doctrine of Protagoras, really based on some such view

as this, we see this taking into account of the dynamics of matter is fully exhibited, though presumably Plato is hostile to Democritus, for he never mentions him. Galen and the author of "The Nature of Man" take in this connection no account of it at all. We get at least a hint of it in "Ancient Medicine" which has more claim to being genuine. Indeed if Galen had commented on the elements of Hippocrates in this book he could not well have escaped the consideration of that point.

Aristotle had declared that essentially the doctrine of Empedocles was one of duality—that for him in reality there were two elements, force and matter. Galen does not pursue the discussion thus far; he only says if there were but one element no sense perception could arise. He thinks the impact of two atoms of the same substance in space could give rise to no quality. Indeed he seems to reject the whole atomic theory because of this apparent inefficiency in originating objective phenomena, since in its terms as familiar to him, "no atom is penetrable or capable of sensation."[4] At any rate this difficulty in the atomic theory for him seems to have been one of the things preventing him from accepting monism in cosmogony. He does not develop here the ground on which his objection to it rests, but the inference is plain we only recognize the definition and limitation of matter, indeed the existence of matter at all by the existence of its attributes or qualities, and these we apprehend through the existence of opposites. A thing is bitter because we know what is sweet, a thing is hot because we know what is cold. This was commonplace among philosophers, and Galen evidently did not consider it necessary to enlarge upon it. Manifestly, if there was only one element, an indivisible portion of matter, opposites could not exist in it and hence knowledge through the senses of matter in general could not arise. We need not stop to discuss this point of view. We can see by reference to the gibe I have quoted he must have thought the contribution of Protagoras to philosophy negligible. If the senses tell us nothing as to realities, he may have thought, they are at least all we have to rest on in cosmology. Most of the philosophers, Plato preeminently, refused to accept this, and we have now long bid farewell to the senses, before Einstein, as the limit of ascertainable knowledge. I cannot see that he reaches this level in philosophy at all. He remains at that of Herbert Spencer, who declared we must start with the knowable. This is all right for any one who knows what the knowable is, but it does not form a very solid basis for those, who, in Galen's words, possess only minds in which they have no confidence. Galen was a positivist, but I confess I am often at a loss in some of the phrases he uses involving this point,

[4] *Ibid.*, p. 421.

though we get a hint as to the origin of some of the narrow bias of his thought in this defence of the "Nature of Man." His pursuit of humoral doctrines in the practice of medicine led him astray. Not only, he says, would man be devoid of sensibility if there were only one element, but incapable of generation too, that being, we may suppose, also an apposition of contraries. Then, if there were only one element, there would be only one disease and one treatment.[5] One may well doubt if the real Hippocrates or Plato or Aristotle ever reasoned with such loose ends as these, but obviously the turn of the argument is again a Spencerian one. In modern phraseology we would say a monistic homogeneity, a real monism, precludes the possibility that out of it heterogeneity can arise. I am not capable of passing judgment on this. I am only trying to trace out his thought in modern terms, and I am forced, in order thus to follow it logically in a modern view, to make some inferences which may be erroneous.

If he apparently falls short of the ancient viewpoint in this respect, and his repetitions serve to remind us of his embarrassment, in quoting them in their varying phraseology we get a suspicion he did not go the limits reached by Democritus and the older philosophers as to the possibilities of the ultimate division of matter. "If any one pricks the skin with the finest of needles, the animal suffers; the point touches only one or two or perhaps many atoms. First suppose only one is touched. No atom can be pierced and it is not susceptible of sense,"[6] etc. His mind almost sticks at the conception of the size of the point of the smallest needle and does not in any event arise to the contemplation of the minuteness of the division of matter nor of its energy demanded even by the ancient theory. Yet so common at Athens, 500 years before, was the conception of the vortex of atoms and their other mobilities that Aristophanes made fun of it on the stage. He finds difficulty, too, in imagining how out of senseless and impenetrable atoms sentiment and easily penetrable flesh can be formed at all. The vastness of the world of being lying between the ultimate atom and the proximate finger pulp his mind could not grasp, "for who will not wonder that flesh when pricked suffers, when its finest particles can not be pierced or made to suffer?"[7] I may be pardoned for lingering thus over the difficulties of a mind in many directions wonderfully acute though lacking that essential of all great minds, imagination, as exhibited in an author so influential as Galen in shaping the future thought of the world. It can not be denied that his mentality was in type that which is often referred to in modern parlance, perhaps not so much now as when positivism

[5] *Ibid.*, p. 436.
[6] *Ibid.*, p. 420.
[7] *Ibid.*, p. 423.

was at flood tide, as the only one for a man of science. I imagine we are to trace to an actual degeneration in the coordinating habit of the human intellect the sinking beneath the horizon of a conception of the cosmos as structurally beyond that furnished by the senses. It has had to be resurrected in our time before further advance could be made in a real knowledge of the fundamental facts of physical science. It was a conception familiar to Empedocles. I am not prepared to say if this submergence, after the great Greeks, is an anatomical, a dynamic or a social phenomenon of degeneration. It seems reasonable to think rather of the latter.

Monism, if not the whole atomic theory, being in Galen's view a doctrine incompatible with observed facts, he approaches a plurality of the elements with more caution than we might expect: "How many there are altogether is as yet undetermined. Therefore we will inquire into the matter." He finds other theoretical reasons, it is true, than the necessity for the supply of a sufficiently large enough variety of combinations, but as is well known he not only accepted the tetralogy of the elements, which Empedocles and his predecessors had presumably derived from Africa[8] but he forced a host of phenomena, by means of the humoral doctrine, into the same narrow numerical confines. We will have to admit that in the then state of knowledge, the acceptation of earth, fire, water, air as elements was the most useful formula possible, however erroneous, for attacking the huge problems of physical science lying ahead of the human mind. Even from these some think "if they are sufficiently multiplied, varied, altered, transmuted, something may arise, which may be of another kind than that already existing."[9] Aristotle, as has been noted, imputed the thought to Empedocles and at least all the modern systematist needs is two, that is, matter and energy, but it is obvious that the former without the latter is unworkable, however successful the modern monist may be in getting along only with the latter. Failing to take note of the thought, evident at least in Aristotle, that energy may be regarded as an element in apposition to matter, really amounting to a dualism, we easily perceive Galen's inability to accept a monism. We have difficulties of our own. The modern human mind falters also, though, astounding as it seems, there are indications of modern man's belief in the possibility of breaking away from the human mind in cosmic theories, and this possibility Empedocles also seems to have played with, but such transcendentalism was not for Galen. However, I am plumbing the shallows of my own mind and ought not to speak for that of my congeners.

[8] THE SCIENTIFIC MONTHLY, April, 1921.

[9] *Galeni de Elementis ex Hippocrate,* Liber I, p. 428.

Galen reminds us of what seemed to him a quite obvious fact. The monist, whether ancient or modern, is, by virtue of his belief in a single element, a mutationist, a believer at least in the multiform aspects of a matter forced on our attention. That all the most ancient philosophers must have been, not only Heraclitus, who so strikingly phrased the idea, namely, that we never step twice in the same river, but Thales and all the rest. Manifestly earth, water, air and fire turning into one another has always been the only way for the monists to keep their doctrine in court. It is all one primordial substance, from which each is severally evolved, and when the argument takes a mystic turn this primordial substance may be unknown to us by our senses, or, out of one primordial element, water, for instance, the others are being continually evolved. The idea of Melissus[10] that the whole universe is compounded of one immutable form of matter is too ridiculous. Aristotle as well as Hippocrates rejects this. It is not necessary to enter into the subtleties of the argument of Parmenides, but it is well to remember that if Plato did not stand in awe of him he respected him highly and portrays Socrates, despite his mock humility and sardonic humor, treating him with more real respect than he exhibits toward most antagonists. Parmenides defended this thesis in the abstract, and doubtless this was one of the reasons why by some historians he is said to have reduced the Eleatic philosophy to absurdities. At any rate Galen is in good company in refusing to accept the ideas of Melissus as worthy of discussion, but when he attempts to give some explanation for the origin of the qualities, he stumbles and falters even in his attack on Athenæus Attalensis,[11] who defended the idea that the qualities were elements, an idea on all fours with the frequent lapse we seem to note in ancient arguments when they treat abstract conceptions as material realities. Moisture in the highest degree as an attribute of matter is water; the hottest heat the ancient knew was fire. In fact, the latter exists before fire, and from it fire is generated when great heat is introduced into fuel.

Under the terms of the argument as they appear in the account of Galen we might think it was a drawn battle, for when dryness and moisture were harnessed up with the other two (earth and air) elements, something else might be deduced. Dryness it would be hard to make into earth, however complete, and coldness could hardly have turned into air. There the facile illustration might have been balked, it would seem to a modern, but that was not the trend of Galen's refutation. We can refuse to believe either was right, but neither is that the point of interest for us. Under what

10 *Ibid.*, p. 447.
11 *Ibid.*, p. 457.

aspects could such doctrine be presented by either side to the controversy with such force as to satisfy any ancient mind that it was an explanation of cosmic philosophy? One of Galen's home thrusts is that cold disappears when heated and the dry when moistened. To us this seems proof sufficient that there is no such thing as the cold or the dry, just as Protagoras had pointed out by non-experimental methods, but this was not for Galen. I doubt if any one generation can ever throw light into all the blind alleys of the workings of the human mind in a former age. In some long gone past, when the doctrine of opposites was a fruitful theory we may conjecture some philosopher, seeking to extend its field of usefulness, pressed the opposites of cold and dry into service and they remained fixed in men's minds for thousands of years. We see Galen close to the path that the hot and the cold are but man's evolved reactions to degrees and kinds of molecular motion. It is true we have no reason to marvel that he did not see it all, but that he should not have stepped out of the path of error and into the path of truth after the early Greeks had shown that man arbitrarily makes himself the measure of the qualities of all things, creates them indeed, is reason for reflection on the imbecility of the human mind. That a part of the difficulty is the fault of the inadequacy of language to express human thought, of which it is called the vehicle, is quite probable. There are all sorts of nouns according to the rules of grammar, some substantive, some abstract, some generic, etc. Ancient thought tended to confuse not only the quality, the adjective, with them, but as moisture was the watery, so white tended to become whiteness and moisture at times became as substantive as water. How much this was a confusion of thought and how much it was a verbal confusion, it is not always easy to discern. There is a book,[12] evidently spurious, attributed to Galen in which we come in full view of these difficulties where according to the title the discourse is about what qualities are corporeal, but we meet with the awkwardness which becomes an actual aberration of thought even in this book on the elements of Hippocrates and in the genuine treatise against Lycus.[13]

For the most part, however, Galen was aware and critical of this pitfall of ancient thought, though he seems occasionally to fall into it himself, for Galen's idea at times seems to be that heat and humidity can differ just as color or pleasure do. The fire may be made from wood or from straw and thus it differs. This throws the modern mind into panic and confusion, and we can not forbear seeing a source of error in such divagations. In his strug-

[12] *Galeno adscriptus liber quod qualitates incorporeal sint*, Liber XIX, p. 463.

[13] *Galeni adversus Lycum libellus*, Liber XVIII A, p. 196.

gle with Athenæus we see the hot becoming pure heat, which is fire, and we then wonder ourselves a little whether qualities are corporeal or not, so bewildered do we become with the phraseology. Is there, then, such a thing as hot heat? That is what Galen seems, when we have become quite helpless, to be driving at in his discourse with Lycus. By means of our appreciation of a hot fire we conjecture he is speaking really of the degrees of heat (the strength of its own activity, Galen puts it), and again we find his feet unawares in the right path. Then a thing is whiter, he says, because it has in it more of whiteness. Thus he hands on to the puerility of the Middle Ages the sophisms of antiquity. Thus he drifts into the common error in primitive thought, much heightened doubtless by the contention of Plato that after all ideas are the only realities; but back of it all we see the mind of primitive man utterly unable to differentiate the material from the spiritual. That was the heritage Plato had from an intellectual heredity already remote in his time. We see the trace of it with especial distinctness in this spurious book on the corporeality of the qualities, deeply tinged with theological infusions.

In résumé we may say, then, that Galen, with the good backing of Hippocrates and Aristotle, denied monistic doctrines and their corollary of mutability. This in reality was probably necessary for the advance of knowledge since the complexity of the problem, as we now know it, was simplified by the false stand taken, but his great predecessors did not anywhere in their genuine works state it as uncompromisingly as did Galen. "It may be boldly asserted earth, fire, air and water are the primary and common elements of all things, since these constitute those bodies which are included in the totality of things first of all and the most elementary to that degree that all other things, vegetable, I insist, as well as animal, are made from these."[14] Whether sensation is present in some one or other of them or results from a combination of them he is not so sure. The perception of the qualities depends on this, he seems to think, and though there are numerous others, those of the hot and cold and moist and dry are the fundamental qualities from which the others arise. All this Galen must have absorbed from his environment and from his great predecessors among the ancient Greeks. He scarcely made a single addition to their philosophy or contributed an argument that had not been used before. Yet his dogmatism, for good or for evil, crystallized the hitherto fluid thought of the older nature philosophers, so that it stood the neglect of a thousand years, and thereafter the assault of new ideas for almost half as long.

[14] *Galeni de elementis ex Hippocrate,* Liber I, p. 456.

THE READING OF CHARACTER FROM EXTERNAL SIGNS

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THE relations between general psychology and individual psychology are important and not hard to grasp. Neither can be separated from the other in practice, but each has its set of problems and its complement of special methods. The problems of general psychology concern the determination of laws and principles applying to the human animal generally, which are either independent of individual peculiarities or inclusive of these idiosyncrasies as definite combinations of general factors, not as exceptions. The problems of individual psychology, on the other hand, concern the discovery of those factors of difference between individuals; thus, ultimately, the description of the important respects in which each individual varies from other individuals, and in as far as classification is useful, the assigning of each individual to the class or classes in which he belongs. The specific methods of general psychology are included under the general term *experiment*; the methods of individual psychology under the term *mental measurement*. The most obvious relation between the two branches is through the fact that reliable mental measures (commonly called *mental tests*) can be developed only through experimentation of the most rigorous kind, and the fact that general principles can be obtained only by taking into account the individual differences of the various reactors on whom experimental work is done. One of the most unfortunate and harmful details of the present enthusiastic movement in the individual psychology, in education, in industry, and in medicine, is the naïve assumption that persons ignorant of general psychology and untrained in experimental psychology can develop and apply mental tests in a useful way without the careful supervision of competent psychologists. The deleterious results of such bungling work on children, for example, are apparent not only in the harm to the children and needless trouble and expense to which parents are put, but also in the prejudices aroused in the public mind against mental measurements as a result of the mistakes of amateurs. Equally unfortunate results are frequent in the legal, medical and indus-

trial applications of amateur psychology. The general recognition of the need of individual psychology in commerce and industry in particular has led to the existence of a class of mere exploiters, many of whom reap large financial rewards from their practices, and whose eventual effect on the manufacturers and business men they victimize is to turn them against the application of real psychology.

Mental measurements have so far been developed to the point where effective determinations of general intelligence are made—determinations which are of value not only for schools and colleges, but also for commerce and industry. No psychologist claims that these measurements are completely satisfactory, and we all know that they are being constantly improved, and will be enormously improved in the future. On the other hand, no one but the psychologist knows the amount of time, labor and personal training required for the development and standardization of even the simplest test. The public, impressed by the apparent simplicity of the materials, assumes that any one can make up a test, and the public is right so far: any one *can* make up a test, and almost every one *does*, but the tests are not worth anything. The public either does not see this, or, if it does see it, assumes that the tests made up by the expert are also worthless. For some of the confusion the psychologists themselves are partly responsible. For example, the nomenclature of "mental ages" as established by intelligence tests, which should never have been allowed to escape from the laboratories, has very much confused and prejudiced the public.

In addition to tests of "general intelligence" (which may most safely be defined as that which standard intelligence tests measure), tests for special intellectual capacities have been developed. We can now measure ability to sustain and to distribute the attention, ability to perceive accurately details of various kinds, ability to learn, ability to avoid learning, and many other special abilities of this class. The field of such measurements is rapidly being extended, and it now requires merely the application of the labor of the trained psychologist to develop systematic tests for the special combinations of intellectual abilities required in any branch of any trade or profession.

But this is the limit to which mental measurements so far have extended. Emotional and moral characteristics are not as yet measurable. Yet we know that these characteristics are of immense importance in all the divisions of life in which we are measuring intellectual capacity. Even as concerns the candidate for admission to college, while it is important to determine his

intellectual capacity, emotional and moral factors ought to be known. There is many a man who goes down or barely survives in college, whose intellectual ability is sufficiently good, but who will not work, or who will get into trouble because of moral delinquency, or whose scale of values is inadequate.

I do not say that we shall never be able to measure these characteristics by the methods of individual psychology; in fact, I think that ultimately we shall compass such measurement. A number of us are now at work on the problem of moral measurements, and I think the prospects for development along this line are favorable. But at present we do not pretend to make standardized measurements of emotional and moral capacity.

Wherever there is a great need, attempts to fill it will be made; these attempts will not all be scientific, and not all made in good faith, especially if there is a prospect of fat remuneration. The historical development of medicine is an illustration of this fact. Medical practice developed long before there was any known basis for it, and the bane of the medical profession to-day is the tendency to apply something in cases where there is really nothing to apply —a tendency against which Osler and other medical leaders have protested emphatically, and with some success.

The past lack of scientific means of measuring intelligence, and the lack of scientific means of measuring moral and emotional characteristics, together with the real need for such measures, has led to the development of unscientific methods of mental diagnosis which are popularly designated as *character analysis.* These methods are based on the assumption that there is a close relation between the anatomy of the individual and his mental characteristics, and that the details of this relationship may be discovered by casual examination, without the aid of statistical methods or experimental procedure, by persons ignorant not only of psychology but even of the rudiments of physiology.

The first systematic attempt at the development of character analysis was made by the phrenologists. The physiologist Gall early in the nineteenth century began to teach that the mental life is largely dependent upon the brain, especially upon the cerebral hemispheres. This fact was not widely recognized before the time of Gall, although it has become a commonplace since then, and Gall's work had a large influence in bringing this recognition about. But Gall and his disciples are also responsible for the introduction into psychology of several misleading conceptions concerning the relation of the brain to consciousness—conceptions which have re-

tarded the development of psychology and which are being eliminated but slowly. Gall and his pupil Spurzheim developed a theory of the relation of the brain to mind which they called phrenology, which means literally the study of the intellect. These phrenologists believed that the different faculties or capacities of the mind were localized, each in specific portions of the cortex or outer surface of the cerebral hemispheres. They further believed that the relative development of each of these faculties depended upon the relative size of the portions of the brain in which the respective faculties were supposed to reside. Highly developed philoprogenitiveness, or love of children, for example, was supposed to depend upon a cortex relatively thicker in the philoprogenitive area than is the cortex in the same area of a person less strongly philoprogenitive. Finally, since they supposed the conformation of the skull to agree with the relative thickness of the cortex it encloses, they assumed the possibility of diagnosing the development of various cortical areas by examination of the outer surface of the cranium. The surface of the head was accordingly mapped off into a number of small areas, each associated with one of the faculties in the phrenological list; and from the relative depression or elevation of these areas the phrenologist attempted to read the "character" of the subject.

We need not dwell upon the series of bold assumptions involved in this system, since, from the scientific point of view, the system is of historical interest only. Quite aside from the further development of phrenology as a technique, it had a profound and on the whole unfortunate influence upon the course of psychobiology for many years. Physiologists and psychologists fell into the habit of assuming that consciousness is dependent upon brain activity in a remarkably simple way, ignoring the complicated interrelations of the various parts of the nervous system, and ignoring the fundamental function of the total nervous system in the control of movements through sensory stimulation. Moreover, both the psychologists and the physiologists accepted even the phrenological doctrine of the localization of conscious functions in specific parts of the cortex, although the functions as thus localized by the physiologists were not the "faculties" of the phrenologists, but a more generalized group, including the senses. It is only within the last fifteen years that psychologists have begun to reject the phrenological theory, and many physiologists still cling to it.

As an art, phrenology had a wide popular vogue and is still practiced lucratively in the United States, there being at least one school in which the system is taught. It has, however, sunk to a position of relatively minor importance, and has been largely

supplanted by newer systems, in part derived from it, and in part derived from still older anatomical beliefs. In these newer systems little emphasis is placed upon the surface of the skull, the major stress being laid upon the contours of the face, upon the size and form of the nose, mouth, ears, brows and eyes, upon the color and texture of the hair, and upon similar anatomical traits.

In one of the most widely known systems, from which many other systems have been drawn, "conscientiousness" is indicated by a broad, bony chin; "benevolence" by a full, rolling, moist under lip; "love of home" by fullness of the soft part of chin just below the lip; "amativeness" by the thickness, moisture and redness of the central part of the upper lip; "cautiousness" by an extremely long nose; "judgment" by a broad, large nose; "observation" by a lowering of the brows at their inner ends and projection of the frontal bone at that point. Musical talent is indicated in this system by an ear of rounding form and fine quality, with a deep bell and perfectly formed rim. Mathematical ability is shown by squareness of the face bones, width between the eyes, and especially by the upward curve of the outer part of the eyebrow. The signs of acquisitiveness are a thick, heavy upper eyelid, with fullness and breadth of the nose just above the nostril. Sometimes an arched, curved or hooked nose indicates the same thing. But in this system the significance of many signs is modified by others; hence, the degree of development of a given characteristic is read, not from a single anatomical sign but from a group of anatomical details, to which I will apply the term *physiognomic pattern*. Thus, a certain relative form or size of one feature might indicate a certain mental trait, provided it is accompanied by certain other details of form, position and size of other features. Linguistic ability, for example, is shown by large bright convex eyes, fullness under the eyes, the rounding out of head above temples, full lips, full cheeks, full throat, wide mouth and chest, large nostrils, length from point of nose to tip of chin, with vertical, lateral and perpendicular width of concha of ear. The physiognomic pattern indicative of well-developed color sense is decided color of the complexion, eyes, eyebrows and hair, clearness of skin, and veins showing through.

By the use of patterns instead of single signs there is secured an elasticity of application of the system, which is of great importance, and to which I shall later refer.

The foregoing samples are drawn from a single system; but this system is one from which a number of variant systems have apparently been derived. There are many systems in use, all equally definite, all equally "successful." Some systems stick

pretty closely to physiognomy; some add signs from the voice, posture, and the anatomical details of arms, leg and trunk. But all these systems agree in two points: They are in the main anatomical, and they are lucrative to their promoters.

The attempts to read character from anatomical signs have not, however, originated in modern times, nor have they been confined to professional character analysts. Evidences of popular associations between anatomical details and especially between facial and mental and moral traits are to be found in the literature of all peoples. "Let me have men about me that are fat," Shakespeare makes Cæsar say. Confluent eyebrows have long been supposed to be evidence of a lecherous disposition; a long nose of meddlesomeness; red hair of passion; and so on *ad infinitum*. As an attempt made in all seriousness to evolve a scientific system of mento-anatomy, I may point to Lombroso's description of the criminal type. It is evident that we have here to deal with tendencies which are widespread, and which are by no means always operating in the interests of private profit. Yet it is the professional character analyst who forms the main problem, since it is his work which furnishes the most pernicious results.

It requires little investigation to convince us that the systems of character analysis now in use have no scientific foundation, and that if any one of them were in part valid, it would be a most marvelous coincidence. None of the authors of the various modern systems shows any evidence of knowledge of physiology or psychology, to say nothing of genetics; nor do they attempt to apply even the simplest principles of statistics or experimental procedure in arriving at their conclusions. Naïve conclusions from selected cases at the best, mere guesses at the worst, are the sole means employed. A study of works on physiognomy strongly reminds the reader of the interpretations of the psychical researchers and the Freudians. Aside from this, the contradiction of system by system would give even the layman cause to doubt. If we consider the signs of the same character trait, such as "honesty," we find it indicated in different systems by quite different signs. If we consider the same sign, such as the shape of the nose, we find it indicating quite different traits in different systems. And yet the claims of any one system to practical success are as well substantiated as are those of any other system.

Nevertheless, the incompetence of the existing systems does not dispose of the question whether there might not be a valid system evolved. In spite of the futile efforts of various would-be flyers, the airplane was invented. We must inquire therefore what possible basis there is for a system of character analysis based on ana-

tomical signs. And we find the answer that there is no known basis on which such a system might be constructed.

We know that the exercise of mental and moral capacities does not change the gross anatomical details of the human being. (Some of the systems of character analysis assume the contrary.) That a man can not, by taking thought, add to his height is true, and is an illustration of a more general law. No exercise of generosity, judgment, musical talent, malice or amativeness can change the form of the nose, or of the ear, or the setting of the eyes, or the form of the brows. If training can not develop anatomical signs, then the putative signs of character must be signs of inherited capacity only, showing the endowment of the individual in respect to capacities which he may or may not have cultivated and developed.

But the results of genetics to date give us no basis for assuming anatomical signs of inherited capacity, except in pure races or relatively homogeneous races. It is true that we may conclude from such signs as the shape of the eyes and the color and texture of the hair that a certain individual belongs to the Chinese race, and hence that he has traits of character common to the Chinese. But the Chinese race, although not an absolutely pure race, is one which is sharply distinct from the white races, and we may expect to find different racial characteristics, although as a matter of fact the characteristics usually imputed to the Chinese are probably due more to training than to heredity. A Chinese boy, brought up under white conditions, is surprisingly like a white boy mentally, although he retains his anatomical race characteristics. In the case of the negro and of other markedly inferior races definite racial mental differences may be admitted. But we must remember that these differences are racial, not individual.

The European races, however, are exceedingly mixed, being the products of the blendings of many stocks, and although it is possible that the original pure stocks may have had specific anatomical characteristics and also specific mental characteristics, we find no linkage of these characteristics in their hereditary transmission after mixture. A remote ancestor of a certain man may have belonged to a stock which had long noses and also had violent dispositions; another remote ancestor may have belonged to another stock, having snub noses and great amiability. The man under consideration may, however, have inherited the long nose from the one stock and the amiable disposition from the other. This fact comes out most clearly in the blendings of the white and negro races. The features of the mulatto or the octoroon give no indication of the relative mental inheritance of the individual from his white and colored progenitors, although statistically the greater

the proportion of white ancestry, the greater may be the probability of white intelligence.

It is possible, although not probable, that our feeble-minded whites inherit their mental defect from certain original pure stocks of low mentality which unfortunately became mixed with the other European stocks, but there are no anatomical signs by which the feeble-minded may be identified. Nor are there any anatomical signs of the criminal, Lombroso to the contrary notwithstanding.

It is true that there are certain exceptions to the generalizations I have made. Cretins, microcephalic and macrocephalic individuals and other distinctly pathological cases show anatomical signs of their mental deficiencies. So does a blind man show that he is deficient in the visual faculty and the legless man show his deficiency in the faculty of locomotion. But these cases are due to specific defects, and have no bearing on the attempts to analyze and classify the common run of humanity. These pathological cases may be easily segregated, and character analysis contributes nothing to our identification of them. In the remaining bulk of the population there is no discernible principle of linkage of the mental and the anatomical.

Finding no scientific basis for the anatomical character analysis, we are now thrown back upon the pragmatic problem. How is it that these systems apparently succeed? And we must admit that they do have at least financial success, for many of the character analysts are making money from their practice on commercial and industrial concerns.

For this success there are two outstanding reasons: first, the actual value of character readings is rarely checked up; second, a few, not many, of the professional analysts, when subjected to actual tests, can make surprisingly good guesses.

As an illustration of the way in which character reading may obtain the prestige of success without being checked up in regard to its accuracy, I may cite the case of a large industrial plant, in which several thousand employees were "analyzed" by a reputed "expert" at a good round price. This expert had a system devised by himself after the usual type, and apparently drawn either directly or indirectly from the older system from which my illustrations were taken and from which many other popular systems are drawn. This self-styled expert told me that in his opinion the systems of several other and better known fakers, whom he named, were defective because they were too rigid. "Now I," he went on to say, "have used in my system all that is worth while in psychology, phrenology and physiology; but I am not hide-bound like the others. When I find a case to which the system doesn't apply,

I discard the system and use common sense." This expert spent several minutes in interviewing each employee, marking on a form card the characteristics of eyes, mouth, ears, hair, head form, etc. Then, combining these records, he decided upon the general mental and moral characteristics of the individual, and upon the particular line of work, if any, in the plant at which he should be put.

The "experting" of these employees was done at the instance of one of the directors of the corporation who had become interested in this sort of "efficiency" through the "success" obtained by it in certain other corporations. By the time the analyses were completed, this director had lost interest in this particular fad, and had become interested in another kind of "efficiency." The results were, of course, pigeonholed; the managers and foremen who were actually working with the employees knew too much to use the readings. But the "expert" went on to the next job with thousands of dollars in his pocket, and with the reputation of having successfully "experted" this corporation, whose directors, being cold, hard business men, obviously would not have put money in the scheme unless it were financially profitable. This corporation, of course, had been influenced by similar considerations. Other concerns had their employees "experted" "successfully," the success having been of the same imaginary sort.

"Success" under the conditions of an actual check up is another matter, and it is said that certain "experts" have, under test conditions, achieved a surprising measure of success. Such tests are made by submitting to the inspection of the "expert" a number of individuals of known and proven capacity in various lines, but who are unknown to the "expert." The "expert" is then required to make a written statement as to the mental characteristics of each person, and these statements are compared with previously prepared statements based on the established characteristics of the test-persons.

Now I can not guarantee that any such tests have actually been successful. I have to restrict my statement to the form "it is said." There are, of course, many chances of erroneous conclusions when the tests are not made under the rigid supervision of psychologists. We know from the alleged proofs of telepathy and of various forms of spirit manifestations that unskilled investigators commonly overlook the most vital points in the test conditions, because they do not know their importance. The records on most tests of this sort have a value of approximately zero, because they contain no reliable evidence on the vital points, however much detailed information is given on other points.

But suppose we assume (although we may have as yet no good grounds for the assumption) that tests of certain character-analysts have given positive results. This would not be surprising. In fact, I should expect to find that some "experts" could produce positive results. Few "experts" are willing to submit to real tests, but those few who are willing must be so because they are confident that they could succeed to some extent, even in a carefully checked test.

We may freely admit that certain persons, working in entire independence of any system, may be able to make some good guesses. Many of us think that we can make good guesses. Our guesses are probably very much less accurate than we suppose, yet they may have some validity. In many cases we have to entrust important matters to individuals as to whose honesty or intelligence we have no evidence except from our guesses based on brief observation of the visible appearance of the individual. There is no reason to suppose that professional character analysts should not be able to make as good guesses as any one else, provided these experts have the requisite native capacity, and provided that, like the one I quoted, they ignore their systems and use common sense.

It is actually a fact that we do make correct judgments about the transient mental processes of other persons without being able to identify the facts on which these judgments are based. If you are talking to some one, and you say something which offends or grieves or pleases him, you may recognize that fact at once, although it may be impossible for you to designate the exact change in his face or voice or posture which is the basis of your idea. You may even make similar judgments when carrying on a conversation over the telephone, in which case changes in the timbre and inflections of the voice alone could give you the clue. You know from the other person's voice that he is offended or pleased, although you may not be able to identify the exact change in his voice which is the important factor. When you have the visual clues from the other person's face, as well as the clues from his voice, your judgments are more definite and more secure.

This whole matter is but a special case of the more general phenomenon of perception and judgment by sign. It is a fact that in much of our perception we perceive meanings without perceiving the signs on which the perception is based. In some cases, the signs could be perceived, if attention were drawn to them; in other cases, the signs can not be discriminated even under the best conditions. I shall not go into this topic in an extended way, both because it is familiar to psychologists, and because it can not be briefly expounded to those without psychological training. I men-

tion it only to show that on this point of character readings we are not dealing with a unique phenomenon, but with a particular manifestation of a general principle which runs broadly through our mental life.

As another illustration of the general principle, I may refer to certain cases of supposed "thought-reading" which are really cases of sign-reading. Many amateurs succeed in catching ideas from other persons, where there is physical relation of such sort that movements of the second person may actually stimulate receptors of the first person, either tactually, visually or acoustically. But these amateurs never succeed if they watch for the signs. They succeed only when they ignore the signs and attend to the meanings. In fact, if amateurs who succeed brilliantly in muscle reading tests become convinced that their performance really is muscle reading and nothing more occult, they can usually do the trick no longer, and this is precisely what we might expect. Similarly, if, instead of watching to see whether the person you are talking to is pleased or not, you watch for the facial changes which indicate pleasure, you will not catch his emotional changes unless the symptoms are extremely gross. The conditions here are not greatly different from those obtaining in the visual perception of depth, where, if you attend to the signs, convergence, accommodation, binocular disparity, and so on, you will lose the depth-effect which those signs would give if they were not attended to.

The important question, therefore, is: What are the signs which tell us something about the mental characteristics of other persons? In the case of fleeting, ideational and emotional changes, these signs are obviously not anatomical; and in the case of fundamental tendencies of mental and moral sorts, we have already shown that there are no known anatomical signs. We are, therefore, forced to the conclusion that in the one case as in the other, the signs are physiological. Changes in the complicated muscular system of the face do occur along with ideas, especially if these ideas are emotionally toned. Changes in the complex musculature of the vocal organs and changes in the arm, leg and trunk muscles also occur. There are, in other words, changes in voice, in features, in posture and in other bodily postures and movements which are perfectly competent to serve as indexes of ideational and emotional changes. Unfortunately, we have not yet succeeded in analyzing more than the most gross of these signs.

Fundamental tendencies in ideational and emotional reaction give rise to habitual modes of expression of the various sorts. Habitual modes of expression, moreover, leave their traces, especially in the face, even when the actual expression is not occurring.

There would seem to be, therefore, a complex system of signs, not only of fleeting mental changes, but signs also of character traits, provided we can make use of them.

Signs of this sort are effective, prior to analysis. Habits of perception and of judgment are built up on signs, without necessitating any analysis or identification of such signs. Moreover, the development of the capacity to catch meanings in this way, if it be possible, depends upon native capacity as well as upon practice. We should, therefore, expect to find exactly what we do find, namely, that there is great individual variation in this apparent skill, and that in the absence of a really comprehensive and accurate analysis of signs, the attempt to attend to signs is a disturbing factor.

Character analysts, if successful under real test conditions, obviously make their guesses just as you or I do. "The systems" can be nothing but obstacles, since they have no real bearing on the problem. But, after having made a guess, the analyst can readily find in his system details which back up his guess, provided the system is elastic, depending upon sign patterns rather than upon hard and fast single signs. We need not assume that successful character analysts, if there are such, go through this sophistical process deliberately. The tendency to construe evidence to suit one's theory, and to recognize the data which may thus be construed, overlooking conflicting data, is too well known and too widespread to need demonstration. One of the important reasons why scientific procedure and scientific methods are necessary is that such procedure and methods are indispensable helps to the avoidance of arbitrary inferences, and even with the best of scientific aids the tendency will sometimes operate.

As a matter of fact, there is no reason to believe that the accuracy and reliability of such guesses as you and I and the character analyst make are very high. But there is reason to believe that if any character analyst does obtain even ten per cent. of accuracy in certain special test cases, he very likely may not know how he gets his results, and may believe that he is getting them through his system, although he really is not.

I have no doubt that those mind-readers, such as Bishop and McIvor-Tyndall, who apparently attained striking results under test conditions, sincerely believed that they were reading minds directly, and not through physical signs. Certainly, they could obtain those results only by ignoring the signs, and it may well be that they would not have been successful if they had known the actual nature of the process. I may mention here the observation I have made that the most successful hypnotists are those who have

no scientific comprehension of the hypnotic process, but who really believe that they are exercising an occult power, or that some "magnetic fluid" flows from their hands to the patient.

On the other hand, it is true that we do, in much of our perception and thought, make use of signs effectively, although we are fully aware of the nature of those signs. In visual depth perception, to which I have already referred, we lose nothing in the perception of depth in pictures and landscapes through an exact knowledge of the signs, provided we do not attempt to attend to those signs in the moment of perception. As another pertinent illustration I may point out that the knowledge that the thinking-process proceeds through muscular signs does not interfere with the vividness and the efficiency of thinking, provided we do not attempt to attend to those signs while thinking.

It is therefore entirely possible that a scientific system of character measurement may some day be developed. Such a system would be based on physiological, not on anatomical signs, and would necessarily be the result of extensive and prolonged experimental work. Even the development of such a system to the point of such relative efficiency as has been reached in mental measurements would require years of work by many and highly trained investigators, just as the development of mental measurements has required.

Although we do not know that it is possible to develop a science of character estimation, serious work in the attempt to find out is highly desirable. Even a definite negative result would be most valuable. In the meantime, a respectable name by which this field of investigation might be known would be practically useful. The term "analysis" and its derivatives can no longer be used in psychology, because, thanks to the efforts of the "psycho-analysts" and the "character-analysts," the terms "analysis" and "analyst" have come to connote superstition and quackery. In the meantime, in the interests of the gullible public as well as the interests of psychology, both pure and applied, we must carry on an educational campaign against "character analysis."

MAROONED IN A POTATO FIELD

By Professor EDITH M. PATCH
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THE circumstance of my exile was in accordance with the rule of contrasts, by which life whets her sense of humor. For it is given even to those who, following the traditions of eight generations, were born within forty miles of Boston to will to go the way of the winds when spring beckons their gypsy instincts; and I confess to taunting visions of elephants dancing in the jungles of one continent and tadpoles named Guinevere disporting in the southern pools of another—glimpses of desire that blurred my eyes a bit as I reached the end of my own so different journey and found myself marooned in a potato field.

An amazing number of the helpless little *solanum* inhabitants of the field were being drawn and quartered and buried at the time. Their graves stretched out in interminable rows, vast cemeteries of tediously straight ridges, alternating with shallow-furrowed barren valleys.

The cemeteries being filled, the surplus *solanums* were being taken to the crematories, called, in the language of the Aroostook, "starch factories." The hearses—long, low-bodies, high-wheeled vehicles locally known as "jiggers"—were laden with staved and hooped coffins, known in the vernacular as "bawr'ls," twenty or so to a jigger; and the procession of these hearses drawn up before each crematory was seldom less than thirty long.

The whole affair that first day impressed me with funereal gloom; a sentiment shared, no doubt, by many an Aroostookian except, of course, the proprietors of the crematories, who were buying for thirty-five cents a barrel the same grade of tubers that, the previous year, had found their way to a different type of market at ten dollars a barrel.

As if to ease my mood with the consolation of sweet companionship, a voice reminded me of a near presence in the familiar words, "Yes, dear, I'm here. Yip, yip, yip, yip!" I laughed—not at the owner of the voice, but at the absurdly huge joy that surged up to welcome him, for it was the first time I had ever noticed that the song of a vesper sparrow is magically sweet. Previously I had always considered the performance a miserably minor affair, but

now even the yips with which he superfluously punctuated the assurance of his proximity borrowed a musical glamor from my pleasure at being greeted—not, mind you, by an elephant dancing in a Kipling jungle nor yet by Guinevere mysteriously frolicking in a Beebe pool, but by the most commonplace sparrow of my acquaintance.

His music was symbolically prophetic, for 'twas to be the natives who were to keep my heart warmed through the dreary initial month of my rustication. Deserving of mention in this connection was little Billy Woodchuck, with whom I was soon on calling terms (though truth compels me to admit that this social function was from first to last strictly one-sided), a frequenter of Stoneheap near Hill-Lane, and 'twas there I met him first.

To say that the pleasure of this meeting was mutual would be to exaggerate, for at sight of me Billy froze into brown and gray shadows among the stones. So I nestled into a fence corner to meditate upon these cool camouflages of wild beasties turned, like a cold shoulder, against all humans, both the just and the unjust. Presently, however, the shadows again resumed the semblance of Billy and crept out on a rock and faced me and whistled. I liked his tune, the better, perhaps, because I could not interpret it.

As I rose to go at the conclusion of my call, Billy slipped to the ground and stood up on his feet like any parlor gentleman. He dropped his hands with Delsartean grace and stood erect and quiet as I departed. When I had gone on a bit along Hill-Lane, I glanced back at a picture that will cheer my memories of woodchucks—great Stoneheap in the near background and in the front little Billy standing between two big rocks with his left hand resting lightly against one of them and his right hand drooping languidly.

When next I saw him he was down in the field, creeping on all fours, with wisps of dried grass sticking out from the sides of his mouth like a fierce bristling mustache. Just why this strange behavior, only Billy, and perhaps one other, more in his confidence than I, can explain. At any rate it intrigued my interest, and when later on the superintendent remarked at Sunday supper that one of the farm hands had taken the gun and had gone out to shoot a woodchuck, my appetite suddenly weakened. The superintendent's interpretation of this murderous errand was that a chuckhole is dangerous in the mowing—a horse might step in and break his leg. But I was skeptical. Haying time was weeks away, and it was not the future and uncertain fate of horse-legs that stimulated this bit of Seventh Day sport on the part of the farm hand. Nothing so altruistic as that. He had suffered, doubtless,

an inevitable reaction from his day of rest and, not being addicted to the type of diversion that some of his associates have been alleged to smuggle across the near Canadian border, he had sought the solace of a gun. Thus, for Billy's sake, I reasoned bitterly to myself, even as that supper tasted bitter to my palate. And I was right, it seemed; for by and by the brave hunter returned with his borrowed gun and the complacent report that he had missed the woodchuck and killed a skunk. Not with the same aim, I took it, though I did not inquire for particulars. What I noted was that he was quite content. His own personal Sabbatical craving for excitement had been satisfied, and charitable interest in the problematic question of broken horse-legs was forgotten. The festive holy-day murder of any one fellow creature had served his purpose as well as that of any other.

Well, Billy was safe for the present. I had that to be thankful for; though I did regret the untimely loss of Mephitis, a large and handsome fellow I had taken considerable pleasure in watching as he scurried with rustling haste about the woodlot from one old stump to another, in frantic quest of buried treasure he seemed never to find. Yes, I mourned the loss of Mephitis, even though for certain inherent reasons I had not hoped to form so close an acquaintance with that black and white denizen of the woodlot as I had with furtive Billy Woodchuck. For I had found that this little chap, who was so delightfully surreptitious about bringing stones and earth out of his dugout and carrying hay in, would venture forth and gaze at me even when I came so near his doorway as six feet. That is, he would if I sat there long enough and quietly enough and if that black rascal of a gossiping Corbie didn't happen to be about and caw down a warning appropriated by Billy. It was remarkable how well Billy understood Corbie's signals. I saw him time and again stand up suddenly, when that busybody sounded an alarm for all the countryside to take notice that an interloper was at hand, and gaze and sniff first this way and then that, quite certain that something had gone wrong. And when he saw the intruder he would sink by imperceptible degrees into his hole, so slowly that even while I watched I could hardly see a motion; only where there had been a woodchuck, erect with drooping paws, there would be at last only a hole in the ground.

Of course in northern Maine there should be partridge cocks strutting about before their families, and antlered moose feeding in the open, and dappled fawns treading their dainty way, and little bear-cubs at frolic. But there are not. At least, in all the hours and all the miles of my three months' residence I did not see one there. For the Aroostook is not a forest, but a potato field.

An old settler, proud as of a miracle performed, stood on a height with me one day and boasted in terms of contrast, "When I first came here, there were forests as far as eye could see."

Well, it was a miracle, man-wrought, a typical agricultural triumph. And the sun of that day, when the heat went to 97 in the shade, scorched my mind with wondering why we, who for generations have been over-anxious lest we suffer after-world hells, have been so industrious in destroying the controlling factor in our water supply in this, our present heaven. During the weeks of dusty drought, when the potato buds shriveled and fell, the query was inevitable: Had we not already overdone the potato acreage a bit? Would the Pine Tree State, in the practical interests of the potato and other economic crops, not have done well to conserve a grove here and there? Not, of course, for emotional or esthetic reasons, but out of cold Yankee shrewdness! These meditations were authoritatively dispelled by the voice of an official visitor to the county—a man from the national Department of Agriculture, who indubitably knows what is good for the future of the potato business. He was saying, with an appraising gesture toward the only remaining parcels of untilled land: "Of course these marshes have some of the most fertile soil. They can be drained and brought under cultivation with even less expense than the work that was involved in getting the forests out of the way."

Farewell, Orchids and Thrushes

But it was not to bemoan the circumstance that fawns and cubs had been ousted and that thrushes were threatened nor to console myself with droop-pawed woodchucks that the treasury of the United States *via* the treasurer of the University of Maine was paying my salary. Mine was a stern commission, and if it was somewhat grimly undertaken it was because I was in personal rebellion against my professional duty.

For I feared that at the close of the season it would fall to my lot to report in the interests of agriculture, to whom I am a servant, that there is no guarantee for healthy potatoes grown within aphid flight of a rose-bush. That was a sad thing to have to face—being hangman to the rose! Surely agriculture is a cruel and exacting mistress. She has beheaded the red cedars in the vicinity of apple orchards, condemned the currant and gooseberry in the interests of white pine, banished the barberry from the neighborhood of grains, because of what fungus specialists have told her. And now, on the word of an aphid-hunter, was the rose to be outlawed from potato land?

These premonitory reflections were soon interrupted by an

event of some importance in Aroostook. The graveyards indicated in the second paragraph of this record were the scene of a resurrection. Like the children in Maeterlinck's "Blue Bird," we saw demonstrated the thesis, "There are no dead," for the long brown ridges were crested with living green. The miracle had taken place—the potatoes were up! But the coming up of potatoes is not so simple a matter in the Aroostook as elsewhere, for that is a north country and because of the frost and for other reasons, too, the crests of green are buried alive. Once and again and again the ambitious plants were subdued. Each time they showed their heads they were heaped over with earth until at last the ridges were so very high and the valleys between were so very narrow and so very deep that the horse-hoes could do no more, and then the aspiring plants were finally permitted to breathe the air that they had repeatedly struggled to reach. Perhaps no one but an Aroostookian treats potatoes so roughly, but the growers there are proud of their school of "high hilling," and a "low hiller" in that country is another term for slacker.

About the time that the plants were progressively and conclusively up, an epidemic of solanimania broke out. Everybody caught it and rushed to potato fields like mad dogs to water. Immediately the vocabulary of the place became suggestive of an insane retreat and everyone chattered in his own vernacular to the confusion of everyone else. The call of the hour, "Let us spray," was observed by all; but the baptismal creeds for potatoes proved as numerous and varied as those for people. There was no quarrel as to the necessity of bordeaux, but the manner of its application seemed still to be in an experimental stage. Arsenic in some form was advocated by all, but chemists nowadays are talking a language unknown to one who grew up in an age when Paris green was in vogue and London purple not quite forgotten. Nicotine sulphate was commonly accredited, but was it actually necessary to hit the aphids with it or did those delicate creatures succumb to the fumes if enough of the stuff was let loose among the rows? Must the underside of the leaves be covered, and, if so, were the undershot nozzles more effective than a drag boom? Was that faithful old standby, the Watson, to be superseded by a haughty new-fangled power sprayer? And was poison dust, if administered at 4 A. M. in the dew, more efficacious than a wet application?

While the spray gangs were still raving about such simple problems and some too involved to lay before an innocent public, other victims of solanimania broke out with symptoms no less pronounced. One man was cherishing about five thousand seedlings in the hope that one of them might give promise of a better potato

than the markets had heretofore welcomed. But there was no time to enjoy a bewildered appreciation of the possibilities of five thousand new potato seedlings before it became evident that the growers of old varieties had been taken with violent spasms of weeding. Now, weeding a potato field does not mean removing plants other than potatoes from the scene of action. Most of that operation comes under the caption of hoeing. When a potato grower "weeds" he digs inadvertent "cobblers" out from among his "green mountains" and removes the adventitious "bliss" or "silver dollar" from his "cobblers." For a potato field in the land where seed tubers are grown is not a mere field of potatoes but a field devoted to some one variety uncontaminated by a chance specimen of some other equally palatable variety. One soon learns in the Aroostook how to tell one potato from another potato.

Nor was the madness of the season confined to Maine. A man from Bermuda roamed about Aroostook County seeking "certified bliss." Out of Vermont came a farmerette in knickerbockers questing from Presque Isle to Prince Edward Isle for "certified green mountains."

Not guests alone but the mails bore evidence that the epidemic was widespread. From one state in the middle west came the announcement (received by a sceptical world) that a strain "immune to potato mosaic" was under successful cultivation. From the state next beyond that came the appeal: "Would you mind giving me some information on the distribution of *Empoasca mali* in your state? As you know, here in —— this insect is a very bad pest, causing ***hopper-burn*** and many other diseases and possibly producing a disease eventually causing the potatoes to run out." And by humorous coincidence, in the same mail as that, there arrived from Burlington, Vermont, an advance announcement beginning, "Tip burn as a physiological disease has been one of the much discussed questions at recent phytopathology meetings since our entomological colleagues have endeavored to carry it over into their camp, ascribing it to an insect and renaming it *hopper-burn.*"

Not science alone became infected, but art as well, as witness: "About the first of next month I shall be in the Pennsylvania potato center. There water-color studies of spud plants are to be perpetrated."

No one, apparently, was immune. I contracted the malady and had as bad a case as any one. A characteristic symptom was a fevered emphasis of one's own particular bias. Mine was the rose-bush. For weeks, as in a delirium, I saw little other than rose-bushes. No devotee of the ancient order of whiskey ever had more vivid visions of reptiles than I of rose-bushes. Indeed, the

knickerbockered farmerette from Vermont protested that she could never again think of me without the memory of my hand waving toward the wayside vegetation while I yelled above the din of the "rattling good" government vehicle: "Beside the last potato field was a rose clump a rod long! See ahead on the right, the whole fence is bordered with roses." Thus from Presque Isle to Frenchville and return, and again from Houlton to Presque Isle.

For the fate of the rose was not alone at stake. My professional reputation as an aphid detective hung also in the balance. My colleagues, the plant pathologists, had challenged me.

It came about thus. A few years previously the plant doctors who spent their summers hobnobbing at Aroostook Farm had informed me that my pet aphid, *Macrosiphum solanifolii*, was spreading their pet potato disease from sick plants to well ones. Said disease (spelled m-o-s-a-i-c but popularly known as "mozik") is not so especially disastrous in the north in potatoes grown for the table; but the south looks to the north for seed, and a tuber with a taint of mosaic in its substance grows, after being transported to the south, to a miserable plant, indeed. Now there is this similarity between the egg business and potato growing—there is no excess profit in the product grown for the table, but for the man who can dispose of his product for purposes of propagation there is a possible fortune. The seed-potato industry, actual and potential, means a great deal to the state o' Maine. And it was threatened, they told me, largely because my "pet aphid," a million or a billion strong, was inserting its beak into the tissue of sick plants and, after imbibing mosaic juice, dispersing to other parts of the field and inoculating healthy plants with the disease.

Their question as to what I would advise under the circumstances made me feel a bit responsible for my insect charges, albeit with something of a lump in my throat, as I replied, "Remove the wild rose-bushes from the borders of fields where certified stock is desired for seed purposes."

My suggestion being met with a sceptical frown from my phytopathological colleagues, I recalled to them the story of *Macrosiphum solanifolii*:

This insect is a migratory species. During the summer it produces viviparous generations abundantly upon potato and certain other herbaceous growths that it accepts as "summer hosts." In late summer and early fall, winged individuals are developed which migrate from potato and other summer hosts to the rose-bush, where subsequently appear, as progeny of the winged migrants, wingless egg-laying females and winged males. The eggs of these apterous oviparous females are deposited on the rose-bush, and remain there unhatched until spring, this plant accordingly being termed the "overwintering host." About the time the new growth of the rose is in its tenderest and most succulent condition in the spring, the aphid egg hatches and the

young insect grows into a wingless viviparous form—the progenitor of all the succeeding generations for the season and hence called the "stem-mother." The daughters of the stem-mother grow up on the rose, part of them with wings and part without. The winged daughters fly forth to seek their pleasure (*i. e.*, a summer host, not hard to find in a land over-run with their favorite sap) and start on the potato vines, the summer colonies, which are augmented a fortnight later by the advent of their nieces from the rose—for their wingless sisters, remaining on the rose, produce winged daughters which migrate in their turn to the potato fields in the vicinity. Thus the cycle runs—the spring migrants going from rose to potato, their progeny unto several generations dwelling on the potato as a favorite summer host; fall migrants winging their way back to the rose where the fall generations, the over-wintering egg and the spring forms reside.

But this recital did not dispel the sceptical frown before alluded to. In fact there was nothing new in the story, for I had told it first as long ago as 1915. The plant doctors had, indeed, but one comment to make. When I wound up with "Obviously the destruction of the wild roses in the vicinity would break the aphid cycle," they remarked quietly, "Of course we may have overlooked them, but we have never observed many wild roses in northern Aroostook."

That was their challenge. It was admirably done, I think. A courteously constrained statement bearing directly on the point under consideration and characteristically conservative, as is the habit of one scientist (if he be discreet) speaking to another. But that brief guarded sentence was charged and I knew it questioned whether I was sure that *Macrosiphum solanifilii* overwintered on the rose, wholly on the rose, and nothing but the rose? As an aphid detective working out the life cycle of this species in Penobscot County, what did I know about the conditions in northern Aroostook where, according to resident observations, wild roses are, at least, comparatively rare?

Certainly that much of professional criticism was implied and possibly a running personal stricture may have been included. At any rate, I found myself wondering whether my colleagues were registering a disappointed conclusion that in failing them at an hour of need I was demonstrating some inherent disability leading to an inference that entomological work in general and the task at Aroostook Farm in particular was after all a man's job! There was, perhaps, a personal "dare" as well as a professional challenge in their significant suggestion that a recommendation to uproot wild roses where wild roses had not been observed to be rooted down seemed hardly in order. Obviously there was but one thing to do either on professional or personal score. The various due official sanctions having been all registered by November, 1920, the next May I laid aside the garb of a laboratory entomologist and donned the khaki of a field scout.

Naturally, first came an intensive quest for wild roses within dangerous proximity to potato acreage. For, as I had taken my "pet aphid" on rose annually since May, 1904, and in seventeen years' collecting had never found the spring generations on any other vegetation, there must be no data overlooked in this particular. How many miles afoot this quest led me, I can not state, but it was as far as one could explore in the days of a fortnight, down one side of the hedge rows and lane rows between farms, and up the other; in and out and round about the bordering woodlots; wading beside marsh fringes in rubber boots; and tramping forth and back along the length and breadth of hillside pastures. And in none of these places did I find a wild rose-bush. News of wild roses in river thickets reached us by way of botanists and fishing men; but (fortunately for one in sympathy with wild life conservation), it did not, in the localities visited, seem necessary to seek them out.

For without that we found rose-bushes, plenty of them, and that along the broad highway! There were dooryard roses near Aroostook Farm, thousands of stems of them, in both directions, within short walking distance. The wheel of the field assistant helped add to the same sort of data; and later by automobile route we saw them at Fort Fairfield, Caribou, Van Buren, Frenchville and all along the roadways between them and Presque Isle. Surely the life-cycle of *Macrosiphum solanifolii* is in no danger of breaking in northern Aroostook for lack of rose sap. That became evident to us all before the summer was over. But incidently there were some very puzzling questions presented by these northern dooryard roses.

Of course it was no surprise to find *some* cultivated roses at and beyond Presque Isle. The plant doctors in attendance on sick potatoes had indicated their presence in the quite logical statement that it hardly seemed probable that cultivated roses would be abundant enough in that locality to keep the aphid supply going. It hardly did! For even at Bangor we are north of the "real rose" zone. We have even here to fall back largely on *Rosa rugosa*, though especially ambitious care provides for cherished ramblers and a limited number of other varieties. But the outstandingly queer thing about the roses of northern Aroostook is that the most vigorous clumps of them are not cherished at all. They grow in neglected masses which give no evidence of pruning shears for two decades at least. And often as not the grandmother of the house would say, "Oh, those are nothing but *wild roses*. Our garden roses," indicating feebler growth, "are here."

That was a riddle unguessed for weeks. Why, when failing in

such places as wild roses are wont to grow wild in, judging from an acquaintance with their ways in other parts of Maine and in other states, should they be so abundantly common in dooryards, especially in old dooryards or spots marked by fire signs or crumbling cellar walls, where once dooryards had been? Your consulting nurseryman can tell you readily enough, but at that time it was a conundrum to me.

But making sure that there were rose-bushes enough to hold all the overwintering eggs of *Macrosiphum solanifolii* necessary for a thoroughgoing aphid plague was not ascertaining that this insect did not also secrete those wee glistening black oval objects on other vegetation as well. And, casting aside the prejudice born of seventeen springs' collections I sought stem-mothers and budding spring-migrants on every kind of plant—tree, shrub, and herb—that I met in a three weeks' tramping. The bicycler, to whom thanks should be rendered, extended the bounds of this quest, as he did others and being without prejudice of previous acquaintance with the tricks and the manners of the insect in question, he may have been the better scout.

However that may be, no tree or herb yielded us spring colonies of our potato aphid, and neither did any shrub except alone the rose, though our search was compounded of diligence and patience.

Nor did the same vegetation yield so largely of other species as might have been expected. Fewer than a century of aphid-species represented our total season's catch. Now fourscore different species of aphids out of a possible four hundred, and not large colonies at that, comprise a meagre showing, leading to the conclusion that 1921 was a poor year for aphids in that locality. A logical explanation of their scarcity was not far to seek. For neat-winged "ladybird" beetles (five species of them) were feeding only less greedily than their brood of scrawny young; gold-eyed "lace-wings," dainty in every respect except as to their brand of perfume, were leaving their stalked eggs where their sickle-jawed progeny might merit the name of "aphid-lion;" several species of bandy-bodied syrphid flies were providing for the continuation of their kind in the same way; a fungus disease was throwing its fatal spores broadcast; and insect-eating birds were as much on duty as could be expected, considering the number of murderous cats wickedly permitted to threaten agricultural prosperity. Now with ladybird beetle, aphid-lion, syrphid maggot, fungus and insectivorous bird (in so far as vouchsafed) in combination against them in a single season, could aphids be expected to wax fat and multiply?

However, nearly two decades of official service in the capacity

of aphid detective leads one to take such seasons with philosophical fortitude. Besides, even the lean years often give significant data and it may not be without interest to mention one "by-product" of the quest of 1921, namely, the accidental discovery that two of our migratory currant aphids spend their summer season imbibing the sap of "willow-herb," a by no mean unwelcome addition to the aphid lore of Maine.

Returning to *Macrosiphum solanifolii*, it may be stated that by this time the scouting done at Presque Isle and farther north brought forth no data conflicting with the tenets that the rose is the only plant in Maine normally serving as over-wintering host for this potato aphid; that in general aphids are conspicuously more abundant in potato fields near rose-bushes; that certain fields in northern Maine, where potato mosaic, though present, was not appreciably increasing, were coincident with an annual scarcity of aphids; and that the logical conclusion was that these same "certain fields" and similar locations might be made well-nigh immune to potato mosaic if the sick plants were to be culled out ("rouged" is the technical rendering of this practice) and the area cleared of such rose-bushes as are not considered precious enough to be served with an annual anti-aphid spray of fumigation.

Does this conclusion thrill the reader (as it does the writer) with an envying realization that a partnership in the business which might be carried on in said "certain fields" would be an amazingly inviting venture? If not, it is because you did not hear what price "per bawr'l" the man from Bermuda was offering for "certified bliss," nor meet the man from Florida who had a fortune to exchange for "certified cobblers."

With the situation thus indicated for Maine, what could be more desired by way of education through compared conditions than a visit to New Brunswick? For New Brunswick and Maine are rivals in the seed-potato market. New Brunswick has cherished a hope that she has some natural advantages peculiar to her location, and Maine has been a bit afraid that might be so. It was, then, with a quickening professional pulse that I accepted an invitation to join, as consulting entomologist, a party of plant pathologists, representing the governments of the United States and New Brunswick, who were touring that province.

We visited during the trip more than eighty potato fields sufficiently to observe and record the significant phytopathological and entomological facts with reference to the potato-mosaic problem. Except for a few generalities, I will spare you all but three locations.

Because there is yet no automobile trail direct from northern

Maine to the Chaleur Bay district, we rode from Perth to Fredericton along the St. John River—a scenic day that makes one glad that there are woods growing in places too wild of contour to be shackled even by stern Mistress Agriculture. Thence our way turned northerly, beyond first one and then another Miramichi River until we reached the "Bay of Heat" where our chief interests centered. On Shippigan Island we visited five potato fields. The aphid count for the three further fields registered zero. That for two twin-sized fields, separated by a tiny meadow, within stone's throw of the ferry landing, was recorded as "a few *Macrosiphum solanifolii.*" The reader is by this time sufficiently initiated into the mysteries of the hunt to see why it was logical at this point for the consulting entomologist to hazard the statement, "There are rose-bushes nearer the ferry-side fields than the other three." But because there were no rose-bushes in sight, the reader may be permitted also to enjoy briefly the flippant phytopathological query as to whether the aphids may not have arrived *via* the ferry line?

However this was really no laughing matter. If *Macrosiphum solanifolii* overwinters only on rose, roses must be there even if they are invisible! I confess to a feeling of panic as I continued what looked to be, on account of the time limit imposed, a vain search. Then, when, in the middle of the shorn meadow separating the two potato fields, I came upon the stubs of a lilac clump, hope revived. For lilacs are not native to Shippigan Island. Where a clump of lilacs make shift to grow, there was once a dwelling, even though the ruins that marked its site are gone. It was as if those lilacs beckoned, and on hands and knees I followed the clue as diligently as any other Sherlock Holmes, and found at last, among the mown grass stubbles, the stubbles, too, of mown rose-stems, short but thrifty. Here then was bait enough to tempt the fall migrants from the adjoining fields—the link that kept the cycle of the potato aphid intact on Shippigan Island. And the thorns that pricked my hands as I plucked an evidential stem from the ground caused a pain that was physical merely and healed completely by the salve of a triumphant spirit.

The next morning a peninsula, a small almost-island, near Shippigan was visited. In the two fields first entered, aphids were disporting themselves somewhat freely. They were less numerous in the third field, fewer still in the fourth, and in the midst of the fifth field I gathered my courage and said, "We are going away from the source of infestation. The rose-bushes are nearer the first fields. If we had time we could find them." To which our guide replied quietly, "We will take time."

The inhabited dooryards in the vicinity were innocent of roses,

but behind the two most heavily infested fields we found a cellar ruin, along the walls of which the prophesied rose-bushes were growing. And also, in this deserted dooryard, long since forsaken, a great mass of the same sort of roses grew clumped over an area as big as that covered by the ruins themselves. That was a neat demonstration of a scientific method, was it not? To tell by looking at a potato field whether one was approaching or receding from a rose-bush. I hoped the phytopathologists did not guess how glorious a moment that was to the consulting entomologist. For the hero of Conan Doyle's pages never felt more keenly a triumph in tracing to a logical conclusion a treasured hypothesis.

But the silly pride that surged up gratefully to greet those roses soon ebbed. There was that about them that touched more deeply. Their true romance was after all not of the brain but of the heart—hearts long since dead. And over the graves of their memories the blossoms of roses smiled that day. For though the sun of August shone upon them, and the reddened rose fruits spoke of a full spring-time blow, a few belated blooms were now in flower. And the frail sweet things echoed as with the music of forsaken gardens.

Those roses, blossoming *in memoriam* over the graves of forgotten homes of yester-long-ago, lure my desire across the sea to the land mayhap where Evangeline's kin once dwelt. Perchance such roses grow even yet in old world places—not dooryards belike, but in untilled tangles; I think so—wild roses, their single blossoms rich of hue, and their leaves a hard clear yellowish green, fresh and clean even under August suns. And if it seem unlikely that the old-world folk brought so common a thing as a wild rose with them, may it not be that their choice double darlings were grafted on a sturdier stock? And after the bitter cold winds of the "Bay of Heat" had blasted the tender growth, the neglected root-stems came unto their own blossoms even in the stern wilds of their adopted land! How otherwise?

Later that same day we saw again that rose of yester-year. This was near "Black Rock." Our guide called a halt there and pointing to the left said, "There and a bit beyond are two fields which registered last year a score of one hundred per cent. mosaic."

One hundred per cent. mosaic! My pet aphids must have been busy. Somehow the fact that there were no roses in sight had ceased to trouble me. I left my comrades clicking their counters in the potato fields and struck out alone along a bordering lane. It led me back beyond the potatoes, beyond a mowing and beyond an oatfield. There I found them—my rose-bushes, a great and ancient mass of them, pushing against a fence that headed a high

bank. When I had returned and made my report, the others of the party went to view the roses with, it seemed to me, a certain curiosity. Indeed, when they caught sight of the great clump, the guide, regarding me somewhat quizzically, demanded, "Do you mind telling me how you *found* these roses, coming directly to them?" And I replied, with a laugh, "Scotch second sight." Who knows? There are times when something seems to click in one's brain as if some charged current from without is turned on, and the resulting action hardly seems one's own volition. And it is a common enough feeling, with reference to any "inspiration," that it "comes to one."

But I am no dabbler in psychic concerns—that way dangers lie for scientific methods. There was, of course, no mystery about finding hidden roses. It needs no diviner with a witch-hazel switch. Doubtless I found the stubs of mown roses on Shippigan Island because I had learned from experience that roses are likely to be planted by the same hands that cherish lilacs; those of the neighboring peninsula from the pure mathematical deduction based on the relative numbers of aphids in the different fields; and those of Black Rock—well, how else than by sheer accident?

At any rate, we saw no more roses like those of Shippigan during the rest of the trip, after we left the old French settlements and visited places settled long ago by the Irish. Not that here were, for all that, a dearth of roses, but they were of a different sort—"wild Irish roses" we dubbed them, though I have a suspicion, based on their habit of growth, general appearance and one dried and crumpled blossom, that they may be what we call in New England "old-fashioned cinnamon roses."

As you see, there was this in common in the single "old-garden roses" of Chaleur Bay, the "wild Irish roses" and the single "wild roses" neighboring potato fields of northern Maine—they grew in or near oldtime dooryards in large massed clumps betokening many years of age.

Surely the rose has nestled too close to the heart of man not to strike with its thorns the hand that is raised against it. Although on entomological evidence it could be sentenced to banishment by authority of crop-pest commissioners, government officials of neither the United States nor New Brunswick would probably care to undertake the unpopular task of exterminating a plant so rooted in human sentiment.

And yet, in the immediate vicinity of northern seed-potato fields, the rose will go. How otherwise? For the man from Bermuda will still come seeking "certified bliss," and the gold of southern states will demand healthy tubers. The northern growers will volun-

tarily attend to a matter that bears so directly on their purses. They have troubles enough without those borne by the wings of migratory aphids.

These were a part of the composite reflections of ninety days that conversed with me as I took a solitary walk across Aroostook Farm the night before I left. The skies were rich with sunset radiance and the glory of rainbow. Under their beauty spread out for interminable miles the potato fields in which I had been marooned for three months by the calendar. As I looked across as much of the green-leaved sea as my gaze could cover, a shiver of revulsion swept over me—a feeling more nearly akin to weary hate than I would think possible to have for any growing plant. There was something hideously manufactured about the landscape, artificially colored with prescribed baptismal dopes; and I detested the whole sprawling amorphous brood of *Solanum tuberosum*.

Was I then at last cured of my attack of solanimania? Had I shaken off the delirious taint of the potato kingdom? Ah, no, no one ever recovers. And a day or so later, when sitting before my long deserted desk at Orono, I drew into place a blank sheet of paper and headed it:

Maine Agricultural Experiment Station
Bulletin No. 303
"Rose-bushes in Relation to Potato Culture"

And the things written under that caption brand the writer as a faithful servant of agriculture or, if you prefer, a servile slave of the spud.

THE REINDEER HERDS OF THE PRIBILOF ISLANDS

By G. DALLAS HANNA
THE CALIFORNIA ACADEMY OF SCIENCES

THE domesticated reindeer of Siberia were first introduced into Alaska in 1892 through the efforts of the missionary, Rev. Sheldon Jackson. The total number brought across Bering Sea was but few more than a thousand when the Russian Government prohibited further exportation. This nucleus has grown enormously and has been divided into a large number of separate herds. The success of the enterprise is apparently assured for many generations and the native race of Eskimos was probably saved from extermination through this single stroke of philanthropy. The people not only derive food and clothing from the herds, but the meat has been sold in ports as distant as Seattle and San Francisco. Nothing but a brilliant future can be foreseen for the industry at this time.

Most of the Alaska herds have been divided and subdivided to such an extent, and the records are so scattered through govern-

Photograph by Dr. L. H. French.

FIG. 1. SIBERIAN REINDEER HERD NEAR NUSHAGAK BAY, ALASKA.

ment reports, that it is difficult to secure data on rates of increase. This, however, is a matter of no little interest in science as well as in industry. It so happens that there are two independent herds on the Pribilof, or Fur Seal Islands, which furnish records of considerable value in this respect.

Through the efforts of Dr. Barton Warren Evermann, when chief of the Alaska Fisheries Service, herds were started on St. Paul and St. George Islands in 1911. The beginning was made with 25 and 15 deer, respectively, and each year a census has been made. The animals practically run wild so that a count of the sexes separately has proved impracticable, but the total numbers are very trustworthy. The counts as published each year in the reports of the Alaska Fisheries are shown in the following table:

CENSUS RECORDS OF PRIBILOF ISLANDS REINDEER HERDS

Year	St. Paul Island	St. George Island
1911	25	15
1912	40	25
1913	52	36
1914	75	58
1915	92	62
1916	111	85
1917	144	96
1918	155	114
1919	164	123
1920	192	125
1921	250	160

It is shown in the above table that the original herd of 25 deer on St. Paul Island has increased to 250. In addition to these an even hundred have been killed for food. On the smaller island of St. George the original herd of 15 has increased to 160 and 89 have been killed for food. The records of killings date from 1915 and are as follows:

REINDEER KILLED FOR FOOD ON THE PRIBILOF ISLANDS

Year	St. Paul Island	St. George Island
1915	3	....
1916	6	3
1917	9	6
1918	12	8
1919	14	22
1920	22	31
1921	34	19
Total	100	89

Thus the total strength of the two herds in 1921 was 350 for St. Paul Island and 249 for St. George Island. When we consider that the animals have had no care whatsoever that reindeer need.

Photograph by Dr. L. H. French.

FIG. 2. FEMALE AND YOUNG OF SIBERIAN REINDEER NEAR NUSHAGAK BAY, ALASKA

the condition would seem to be very satisfactory and Dr. Evermann deserves great commendation for having overcome the many obstacles in the way when the introduction was made in 1911. Persons familiar with the raising of these animals in Norway state that in 10 years the original herds of 25 and 15 should have increased to 500 and 300 respectively, if they had received proper care and attention and if the surplus males had been regularly removed. A much larger number could also have been taken for food. Nevertheless, the records possess a peculiar interest because the herds have been allowed to revert to the wild state.

The average increase each year has been a little more than 33 1/3 per cent. when the animals killed are added to those living. It is a little less than that figure when only those living are considered.

The full significance of this may be better understood if comparison be made with other animals which bring forth but one young each year, such as the fur seals, for which the Pribilof Islands are famous. In the same ten years the herd of these animals has increased at an average rate of only about eight per cent. per year. The difference in the rate is not due to the longer breeding period of the reindeer, but to the enormous destruction of the fur seals in the sea by killer whales. At least fifty per cent. of the young born each year fail to reappear the third year following, and the work can be laid only to the killer, because the actual amount of pelagic sealing by man is small.

As stated above, the reindeer have reverted to the wild state. The business of the inhabitants is the taking of seal and fox skins and they give little attention to the deer. The animals are never herded or placed in corrals. They resort to the distant parts of the islands where they seldom see human beings and have become almost as wary as wild caribou. No use is made of them at all except for food.

Some of the surplus males are now taken each winter and the herds show considerable improvement since the practice was started in 1915, as a careful examination of the above tables will demonstrate. Before that time the fighting of the males was a detriment to the herd in several ways. They not only killed or injured each other, but they injured some of the females as well.

The killing is done with high powered rifles, not a commendable practice, but the only practicable method when the animals are allowed to become so wild. The shooting not only makes them

FIG. 3. ST. PAUL ISLAND REINDEER HERD IN 1919

wilder, but results in the occasional killing of a first class female by mistake. In one case one male and two females were killed with one shot fired into the herd.

As to the already great value of the herds to the U. S. Bureau of Fisheries, which administers the affairs of the islands, there can be no question. Each deer killed is equal in food value to two sheep which are imported at about $15 per head on the average. Thus the equivalent of about 100 sheep was taken in 1921. The value of this food would seem to warrant the employment of capable herders and the erection of proper corrals for the care of the animals. This would not only enable the removal of the correct number of males without the uncertain method of shooting, but would enable the authorities to remove old and useless females, as any wide-awake stockman would do.

If the herds continue to increase during the next ten years as they have in the past ten, there should be about 2,500 deer on St. Paul Island in 1931 and about 1,600 on St. George. So large prospective numbers as these should receive care and attention, because the annual increment will furnish a supply of excellent

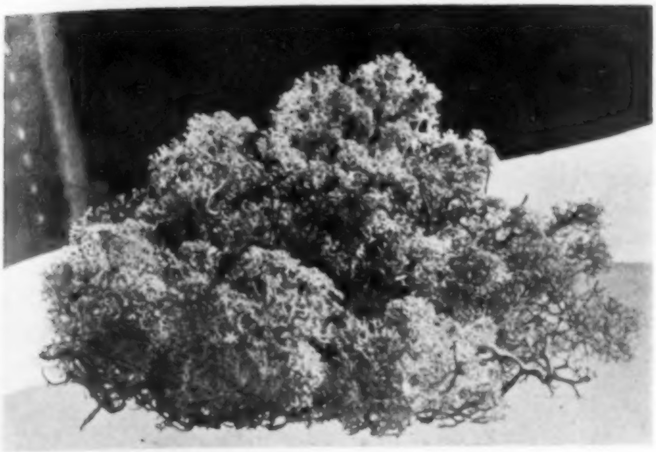


FIG. 4. LICHENS KNOWN AS "REINDEER MOSS" FROM ST. PAUL ISLAND, ALASKA

fresh meat, sufficient to supply all the needs of the islands for many decades.

Since the reindeer depend upon slow growing lichens, the familiar reindeer "moss," for food in winter, care should be taken that the herds do not increase beyond the supplies of these plants. The islands are small and not all of the surfaces are suitable for grazing by any means. It has been stated that this "moss" on the mainland of Alaska replaces itself in about seven years. Observations made by me on the Pribilofs indicate that there it grows more rapidly. Areas completely denuded in 1914 were regrown by 1919. The difference in rate of growth is believed to be due to the longer growing season on the Pribilofs and the much damper climate.

One of the most important problems to be solved in connection with the Pribilof herds is the determination of the maximum numbers which can be supported. The government should determine this before it is too late. With competent herders in charge of the animals it would not be a difficult undertaking.

These herds are under particularly fine circumstances for observation and study. The most distant part of either island can be easily reached in a day by a man on foot. Strict control is constantly maintained by the agents of the government; or at any rate it can be maintained when desired. More is known of the wild life of the reservation than of any similar area in our northern territory. It would seem that here is the place to maintain model reindeer herds and to determine many of the needed facts for the propagation of these animals on a large scale. At no other place are conditions so favorable. The animals have no enemies

on the islands. Dogs are not permitted to be landed and mosquitoes or other injurious insects are absent. By some queer but fortunate turn of fate, ticks or parasitic flies were not imported with the original shipment. No new stock has been brought in, so that inbreeding and crossing could here be studied to the greatest advantage.

It may be of interest to those who so vigorously opposed the introduction of the animals in 1911, and actually prevented it

FIG. 5. LICHENS KNOWN AS "REINDEER MOSS," OTHER SPECIES, FROM ST. PAUL ISLAND, ALASKA

when first proposed by Ezra W. Clark back in 1905, to learn that the reindeer have not interfered in the slightest degree with the fur seal herds or with the work of securing their skins. The deer seldom visit the beaches and have not to my knowledge been observed on a fur seal rookery when it was occupied.

It is to be hoped that the Bureau of Fisheries will grasp the opportunity presented, and by careful study and care of its reindeer herds, furnish the people of Alaska with information which will be of inestimable value in the industrial development of the north.

THE PROGRESS OF SCIENCE

CURRENT COMMENT

By Dr. Edwin E. Slosson

Science Service

THE SCIENCE OF KEEPING COOL

The problem of hot weather is not, as some folks seem to think, how to keep the heat out. It is how to get the heat out. The body temperature sticks pretty close to the normal point of 98.6 degrees Fahrenheit and unless the air temperature gets above that we do not take on heat from the air.

For heat, like water, runs down hill. It passes from a higher to a lower temperature. The steeper the grade the faster the flow. That's where the difficulty comes in. For we have to keep our internal temperature at the normal point, whatever it may be outside, and there is only a thin skin and some clothes between. When the weather is cold we have no trouble in getting rid of the heat we produce from the food we eat, for it runs off rapidly, so rapidly that we have to put on more clothes to check it. But as the air temperature rises nearer to that of our own the current of escaping heat slows up and finally sets back if the temperature goes over 99.

We shut down the furnace in our houses when winter goes. But we can not shut down the furnace inside of us because the works would stop. Our internal furnace serves as a power-house as well as a heater. We have to keep the engine going night and day and that requires a certain amount of fuel, though of course we do not need so much in summer time.

A man who is not doing much, "just up and about," will have to have 2,400 calories of food a day. If he is working, he will need 500 or 1,000 more. So even if he lives in idleness he has to get rid of heat at the rate of 100 calories an hour on the average, which is about as much heat as is given off by four ordinary electric lights.

Now this heat can be got rid of in two ways. It can run away or be carried away. It will run away if the temperature of the surrounding air is enough lower than the body and there is enough, not too much, cloth between.

It can be carried away by water. Water can carry more heat without showing it than anything else in the world. A quart of water will take on a calorie of heat and only show a rise of less than two degrees Fahrenheit. When a quart of water evaporates it carries off about 500 calories. If, then, you sweat a quart this is the quantity of heat you are getting rid of, provided the perspiration evaporates from the skin. Here is the difficulty. If the air holds already all the water it can take up, then you can not get the benefit of the absorption of heat through evaporation. So when the air is saturated with moisture, or, as the weather man puts it, when the humidity is 100, then you say "this is muggy weather" and you complain that the heat is intolerable even though the thermometer does not stand high.

Your own internal thermometer, your sense of temperature, only registers loss and gain. You feel warm when you are gaining heat. You feel cool when you are losing heat. You can only lose heat by radiation when the air is cooler than your skin. You can only lose heat by evaporation when the air is drier than your skin. It is only the layer next

ALFRED GOLDSBOROUGH MAYOR

In whose death biological science suffers a severe loss. Dr. Mayor was director of the department of marine biology of the Carnegie Institution of Washington

to your skin that counts. If the air there has a temperature of 99 degrees and a humidity of 100 per cent., then you can not get cool either way. In that case you must drive away the layer of hot moist air and let some that is drier and cooler get at your skin, which you can do by means of a breeze, or, in default of that, a fan.

GASOLINE AND ALCOHOL

Before prohibition the per capita consumption of gasoline and alcoholic beverages was about the same, twenty gallons a year. Now the consumption of alcoholic beverages is theoretically reduced to zero while the consumption of gasoline has risen to seventy-seven gallons per capita.

But we may live to see these ratios reversed and gasoline decline while alcohol rises until vastly more alcohol is manufactured. For if alcohol comes into general use for fuel purposes vastly more must be manufactured than in the days when it was thought fit to drink. Now that the law will not allow us to drink liquor, we have alcohol to burn. And so soon as men get accustomed to regard alcohol as fuel instead of as food, the vexatious restrictions that

have been imposed upon its manufacture and sale for the last five hundred years may be removed. When that day comes the government will be urging people to set up home stills instead of confiscating them, and this will enable spoiled grain, unsalable fruit, sawdust and all sorts of wasted stuff to be converted into power on the spot.

For alcohol can be made out of more different things than almost anything else in the world, as those who have experimented with home brew have found out. Any sugary, starchy or woody material can be converted into alcohol, directly or indirectly, and there are millions of minute plants always hanging around ready to undertake the job of conversion for a bare living.

But if we have to shift from gasoline to alcohol we shall have to hunt for the cheapest and most abundant material to make it from, and it is high time that the hunting began. The saving of waste foodstuffs would not suffice. If we used corn it would take more than a quarter of our corn crop to make enough alcohol to take the place of the gasoline now used and we shall want to use more in the future as our desire for power increases.

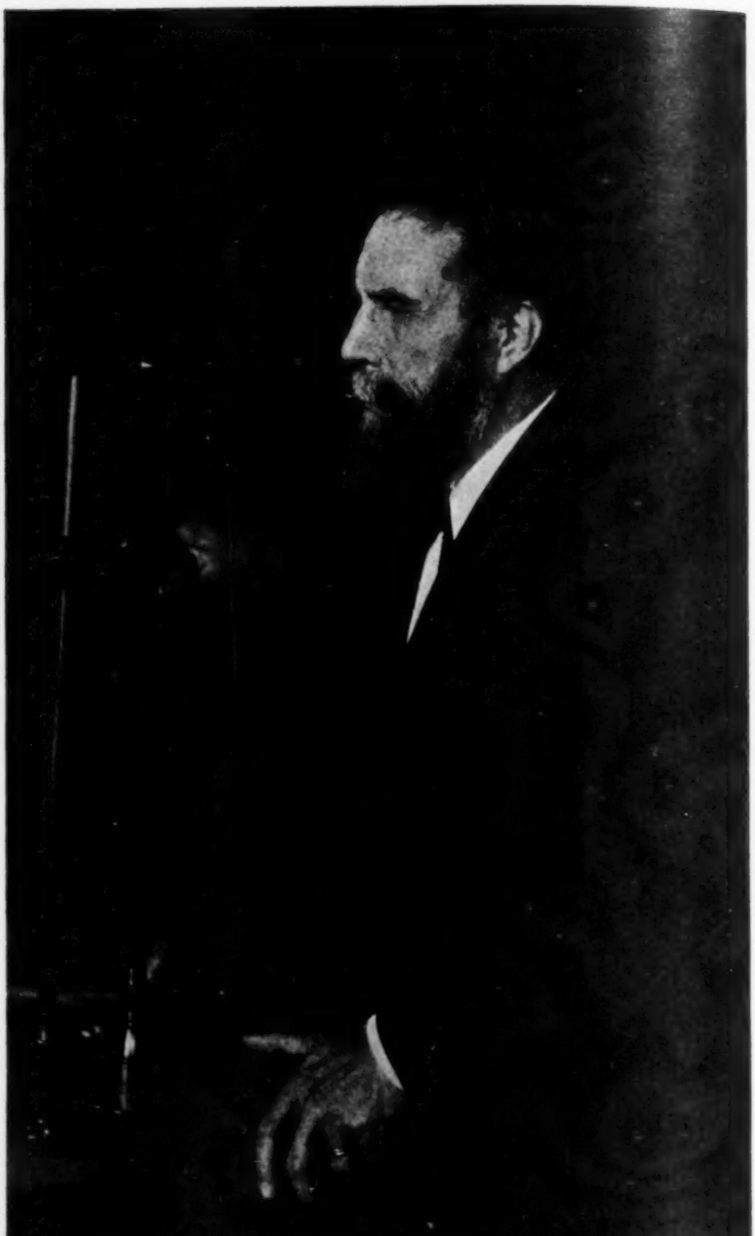
Probably it will be found that the tropics will grow the largest crops of saccharine material suitable for alcoholic fermentation in a season and, if so, this neglected region will assume the importance that the coal field countries now possess. There will then be hot strife for hot territory, and the alcohol power will rule the world. Dr. Diesel, believing that his engine using heavy oils—mineral or vegetable—would take the place of the gasoline engines burning light fluids like gasoline or alcohol, foresaw the time when palm, peanut or some other tropical oil would be the motive power on which civilization would depend.

There are, of course, many other conceivable possibilities. We may distill cellulose directly instead of converting it into sugar and then fermenting it to alcohol. The chemist may get up some carbon chain or ring with all the hydrogen it can hold that will make a better fuel than anything found in nature, but he will have to have something to make it out of and that something will have to be grown. Unless we find some other source of power than combustion, we must eventually grow our fuel as we use it, for fossil fuel will not last forever. We must find a way of using the sunshine of to-day instead of that which fell upon the earth in the Carboniferous Era.

FROM COMPLEXES TO GLANDS

How swiftly the spotlight of popular interest shifts from one part of the stage to another! The eyes of distressed humanity turn eagerly toward any quarter that appears to promise health and happiness. A few years ago psycho-analysis was all the rage. Now endocrinology is coming into fashion. Those who recently were reading Freud and Jung have now taken up with Berman and Harrow. Those who formerly were rushing to have complexes extracted are now anxious to have glands implanted. Away with psychology! 'Rah for physiology! Anything hailing from Vienna is bound to boom.

As fads there is not much to choose between them. Popular expectations always run far ahead of the march of sober science which must make sure of every step as it goes. Both these have a certain foundation of fact, and promise much for the future though neither can fulfill the anticipations of the public at present. But the scientific basis of the glandular idea is much more solid and substantial. An emotional



PROFESSOR KONRAD ROENTGEN

Who has retired from the chair of experimental physics at the University of Munich. Professor Roentgen discovered the Roentgen or X-rays in 1895

complex is after all a figment of the imagination, but when you get out a chemical compound, extracted, purified and identified, you have hold of something tangible and when you put it back into the patient you can regulate the dose and record the reaction.

Physiologists now lay many bodily disorders, as capitalists do industrial disorders, to the pernicious activity of "agitators." The physiologist, since he prefers to talk Greek, calls them "hormones," but the word means the same. At least a half dozen of these hormones are already known. They are marketed among the four hundred by-products of our packing houses. Two of them, thyroxin and adrenalin, are definite chemical compounds and can be made synthetically. Soon the chemist will capture them all and possibly he may make stronger and better ones than the glands turn out in their old-fashioned way. There may be giants on the earth in those days, such as Wells foretold in "The Food of the Gods."

These hormones determine our temper and our temperament. They decide whether we shall be tall or short, thick or thin, stupid or clever. They mold our features and control our characters. A minute amount of certain secretions will make one more masculine or feminine, older or younger.

But until the chemist can manufacture them in the laboratory and we can carry them in a vest pocket case, we are dependent upon more or less active and impure extracts from the glands to supply our functional deficiencies. Or—and this is the latest sensation of the hour—we may be grafted with a gland from some animal. Unfortunately, the glands of the lower animals do not set well in the human system. Those of the apes work best, which goes to prove that they are blood relations of ours, Mr. Bryan to the contrary notwithstanding. In any case the relief is not likely to last long, for the borrowed gland may succumb to the same influences that invalidated the natural organ.

In spite of the startling experiments of Voronoff and Steinach on the rejuvenation of rats and sheep, science is not yet in a position to meet the old demand for an elixir of life. Dr. Brown-Sequard, of Paris, who thought thirty years ago that he had found something of the sort in an extract of goat glands, did not live long enough to demonstrate his discovery. The rich old man, who went to Vienna to regain his youth and came to London to prove the success of Steinach's operation, died on the eve of his lecture on "How I was made twenty years younger." But there will be plenty of people eager to try the new methods, urged by the same motive that drove Ponce de Leon to seek the fountain of immortal youth in the vicinity of Palm Beach.

SCIENTIFIC ITEMS

We record with regret the death of Alfred Goldsborough Mayor, director of the department of marine biology of the Carnegie Institution; of James McMahon, emeritus professor of mathematics at Cornell University; of Dr. Edward Hall Nichols, professor of clinical surgery in the Harvard Medical School; of Dr. W. H. R. Rivers, of the University of Cambridge, known for his work in anthropology and psychology; of Prince Albert de Monaco, distinguished for his oceanographic studies; and of Professor Edmund Weil, who died from typhus contracted by infection in his laboratory at Lemberg.

The John Fritz medal has been presented by the board representing the leading engineering societies to Senator Guglielmo Marconi. The medal is presented for achievement in applied science as a memorial to

John Fritz, who was the first recipient. Other recipients of the medal have been Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, Charles T. Porter, Alfred Noble, Sir William Henry White, Robert W. Hunt, John Edison Sweet, James Douglas, Elihu Thomson, Henry Marion Howe, J. Waldo Smith, George W. Goethals and Orville Wright.

Dr. George Ellery Hale, director of the Mount Wilson Observatory and chairman of the National Research Council, has been appointed a member of the Committee on Intellectual Cooperation of the League of Nations, which was recently formed to promote research throughout the world and to facilitate the interchange of scientific information. Other scientific members of the committee are Professor Einstein and Mme. Curie.

The American Museum of Natural History has had its endowment largely increased through contributions from John D. Rockefeller, Jr., George F. Baker, and the settlement of the estate of Amos F. Eno. The Rockefeller gift of $1,000,000 will make it possible for the museum to carry on its educational work throughout the city without impairing funds needed for scientific research. Mr. Baker's gift of $200,000 supplements a recent one of $100,000.

Arrangements have been made to supply Russian men of science with the results of American scientific work accomplished since 1914. Under the chairmanship of Dr. Vernon Kellogg, secretary of the National Research Council, an American Committee to Aid Russian Scientists with Scientific Literature has been organized. Other members of the committee are Dr. L. O. Howard, chief of the Bureau of Entomology of the Department of Agriculture, Dr. David White, chief geologist, U. S. Geological Survey, and Dr. Raphael Zon, chief, forest investigations, U. S. Forest Service. This committee has arranged with the American Relief Administration to receive contributions of scientific literature at New York and transport them to Russia. It is a voluntary and temporary organization with headquarters at 1701 Massachusetts Avenue, Washington, D. C.